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PRODUCTION METHODS AND THE KEEPING QUALITY OF CHURNING CREAM[1]

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Since the start of the war the flavour quality of Alberta creamery butter has retrogressed. This retrogression has been related to the lowered quality of the incoming raw cream which in turn is thought to be largely a reflection of the farm labour situation.

There is a wealth of knowledge of the relation of milk production methods to the keeping quality of fluid milk held at different temperatures. No such body of data relative to churning cream exists and there is practically no available information applicable to Alberta churning creams.

Churning cream production methods differ from market milk production techniques in that churning cream is usually delivered to the plant less frequently than is market milk and it conforms to a different set of grade standards. It has become customary to assume a necessity for either frequent delivery or mechanical refrigeration, if the highest grade of churning cream is to be attained. Either alternative is expensive.

For differentiation of grades the Alberta Cream Grade Standards depend on titratable acidity (expressed as percentage lactic acid), flavour and certain other characteristics.

Assuming clean flavour and uniform consistency, Special Grade, the highest grade applicable to churning cream, permits a maximum titratable acidity of 0.3 per cent, while for First Grade the titratable acidity may reach 0.6 per cent. Creams of higher acidity or with certain flavour defects, etc., qualify for Second Grade and very objectionable flavours cause degrading to Off Grade.

It is generally assumed that Special Grade cream will churn into First Grade butter with a flavour score of not less than 40 and that First Grade cream will churn into First Grade butter with a flavour score of 39. The Cream Grade Standards are, thus, based on butter grading standards. In general, 40 score butter probably has superior keeping quality to 39 score butter. There is a mandatory minimum differential of 2 cents per pound in favour of Special Grade butterfat.

The purpose of the present study was to gather information, if possible, which will permit the producer to deliver churning cream of maximum quality with minimum expense. The study is limited to bacteriological considerations, does not include defects not induced by bacteria, and was conducted during the summer months only.

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METHODS

Creams were collected in sterile containers at the point of origin, i.e., a local creamery (plant creams) and Farms A and B and transported immediately to the laboratory. They were then dispensed into sterile screw-cap medicine bottles and sterile covered test-tubes which were stored in water-baths held at the required temperatures. Accordingly, daily sampling was accomplished without disturbing any bulk cream.

Standard methylene blue reduction and plate counting techniques followed Standard Methods for the Examination of Dairy Products (A.P.H.A., 1943) except that plate incubation temperatures were 25° C. The titratable acidities (T.A.) were determined by the usual procedure and the grading followed official provincial practices. The stored creams were subjected to the various tests daily. The first few creams were stored at 40° F., 50° F. and 60° F. but the later samples were stored at 40° F., 45° F. and 50° F.

Farm A was producing a high quality cream from machine-drawn milk. Milk drawn by hand into sterilized utensils and separated by a sterilized separator was specially produced on two occasions for the purpose of this study.

Farm B was ordinarily producing, by hand milking, a cream of much lower quality and was experiencing difficulty in delivering Special Grade cream twice weekly. Cream 20 was morning cream produced as usual on this farm and held at 46° F. till it was collected in the evening. Cream 21 was from the evening milking on this farm, the only change being that all the utensils, including the separator parts, were sterile.

The points of origin and the initial reduction times, plate counts and titratable acidities of all the creams are given in Table 1.

RESULTS

Plant Creams

To study the keeping quality of creams of high bacterial content, a number of Special Grade creams were collected on delivery at a local creamery. In each case these were judged to be representative of the best creams received at the creamery on the day of collection. These were, of course, creams of unknown history and had been held on the producing farms for unknown but varying times at unknown but varying temperatures. The condition of these creams on delivery at the plant is given in Table 1 from which it is seen that acid production was well progressed except in creams 12 and 17. In these two creams it is probable that acid increase was just measurable. In no case did the cream remain in Special Grade at 45° F. for longer than 3 days (Figures 1 and 2).

There is a general trend toward lowered keeping quality as the bacterial content rises. There are some inconsistencies when different holding temperatures are compared, probably caused by differing bacterial floras and varying selective effects of the temperatures. Certainly, in practice, large bacterial populations do not permit infrequent delivery of the cream to the creamery and simultaneous attainment of Special Grade.

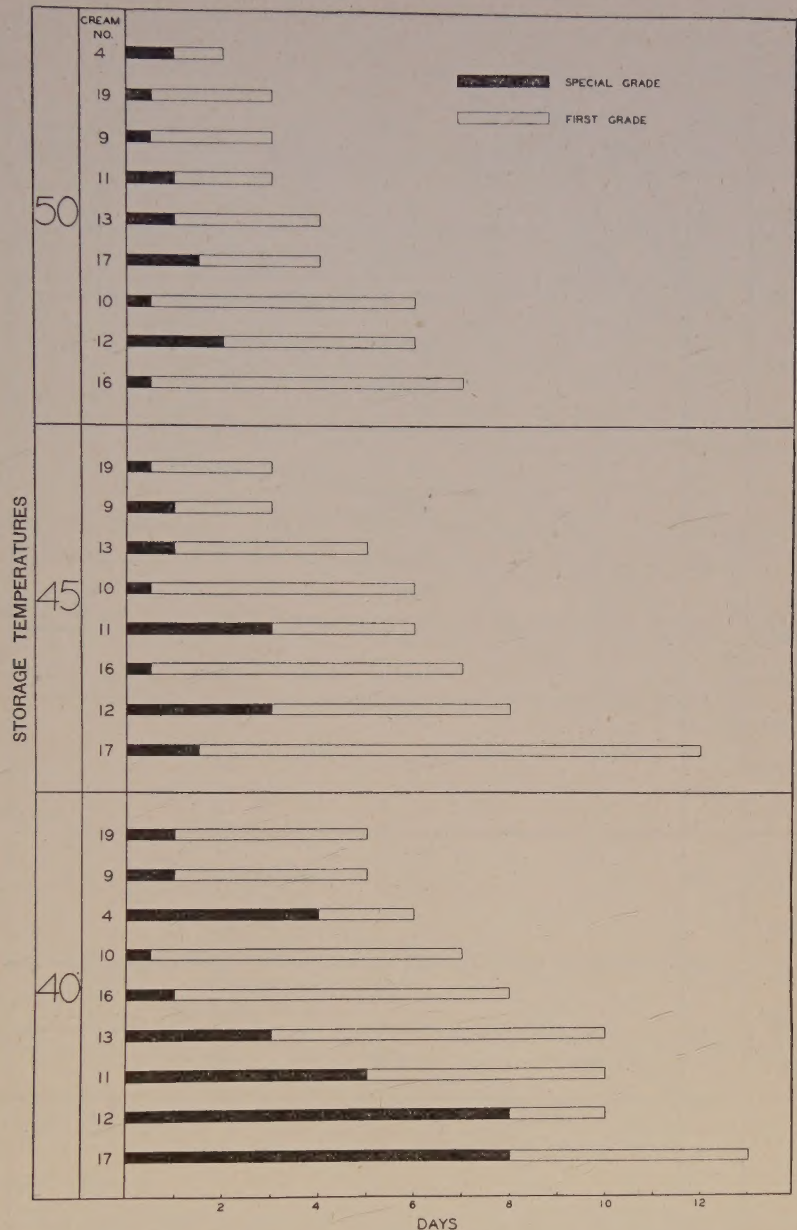

FIGURE 1. The number of days plant creams remained in Special and First Grades at various storage temperatures.

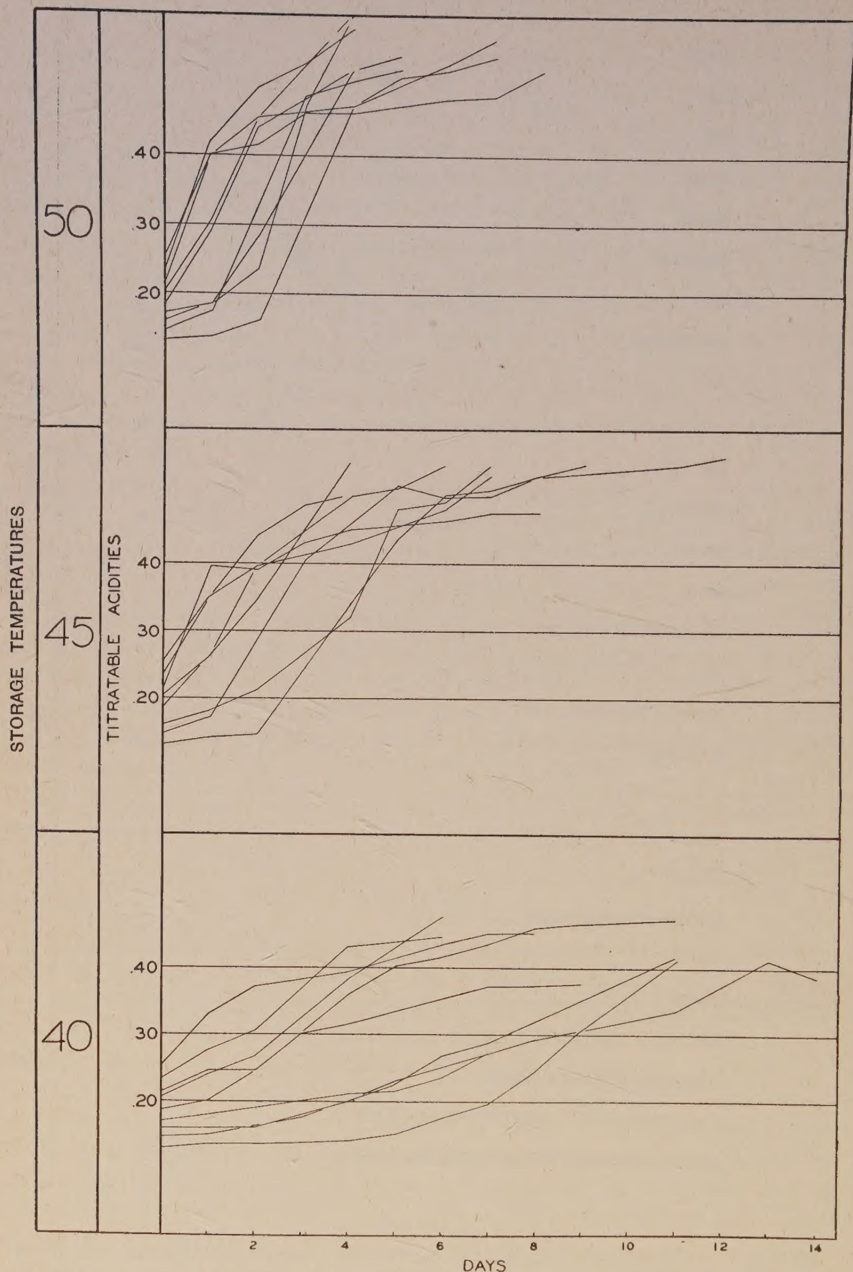

FIGURE 2. The titratable acidities of plant creams stored at various temperatures.

TABLE 1.—ORIGIN AND INITIAL CONDITION OF THE CREAMS

Cream		T.A.	Reduction time in hours	Plate count
Source	Number			
Farm A	1	0.15	9	—
	2	0.125	>10	—
	3	0.130	7½	**3,000
	5	0.115	> 9	**320
	*6	0.125	>15	150
	*7	0.115	>10	1,500
	8	0.125	9	9,800
	14	0.110	7¾	10,700
	15	0.120	7¾	7,800
	18	0.095	8¾	3,000
Plant	4	0.170	½	—
	9	0.205	0	>30,000,000
	10	0.255	0	>30,000,000
	11	0.160	1	91,000,000
	12	0.130	4½	4,400,000
	13	0.185	0	177,000,000
	16	0.215	0	310,000,000
	17	0.145	0	77,000,000
	19	0.235	0	253,000,000
Farm B	20	0.115	1	5,500,000
	*21	0,115	10	12,500

* Sterile utensils.
** Plates incubated at 37° C.

Farm A Creams

This farm was known to be producing a cream of superior quality. The metal milk utensils were ordinarily sterilized just prior to use by immersion in water at or near the boiling point. The milking machine inflations were kept filled with a chemical disinfectant between milkings. The standards of general cleanliness were high. The substitution of laboratory autoclaved utensils did not raise the keeping quality of the cream from this farm (Creams 6 and 7).

The first few creams from this farm were stored at 40° F., 50° F. and 60° F. Even the creams of the lowest bacterial content had such poor keeping quality at 60° F. that twice weekly delivery of the cream would

not assure a grading of Special. Lower temperatures are easily attained in this area without recourse to other than well-water refrigeration. Therefore, 60° F. was adjudged not to be a practical storage temperature and experiments at this temperature were discontinued.

In earlier studies conducted by this Department it was found that the waters in the wells of this district are rarely, if ever, above 45° F., while not a few have temperatures of 40° F. or below. Therefore, experiments on the keeping quality of creams stored at 40° F. were deemed to have practical value.

The results with Farm A creams are summarized in Table 2 and Figures 3 and 4. These creams of low bacterial content graded as Special for at least six days when stored at 50° F. and for at least ten days when stored at 45° F. When stored at 40° F. the creams remained in Special Grade for two to four weeks. Such a long holding period is not to be recommended in practice, however, because it is conducive to the appearance of serious defects of non-bacterial origin, while the economics of the butter industry demand no such infrequency of delivery.

In some cases the day's grading placed a cream in First Grade while subsequently it graded Special. There was noticeable inconsistency in this regard except that it never occurred during the first thirteen days of storage. The cause of this inconsistency was not determined but it may have been an artifact introduced by the non-representativeness of small lots of the original sparsely-populated creams. If so, then this inconsistency would not appear in the grading of commercial bulk samples.

Table 2.—Number of days Farm A creams remained in Special and First Grades at various storage temperatures

Temperatures, ° F.	Days			
	Special grade		First grade	
	Minimum	Maximum	Minimum	Maximum
60	2	4	5	8
50	6	9	9	15
45	10	17	12	19
40	17	30	17	>34

Farm B Creams

For assurance that utensils are responsible for the major bacterial contamination of ordinary churning creams, a farm producing a cream of inferior quality was chosen for study. This farm was experiencing difficulty delivering Special Grade cream twice weekly, despite a holding temperature of 46° F. Between a morning and an evening milking, all the utensils were sterilized and the results for both the morning and evening creams are shown in Table 3 and Figures 5 and 6. Cream 20 (morning cream) was high in bacterial content and had very poor keeping quality. Cream 21 (evening cream) was low in bacterial content and had excellent keeping quality. The cream of superior quality was produced by no other change than to sterilize all the milk- and cream-contact surfaces.

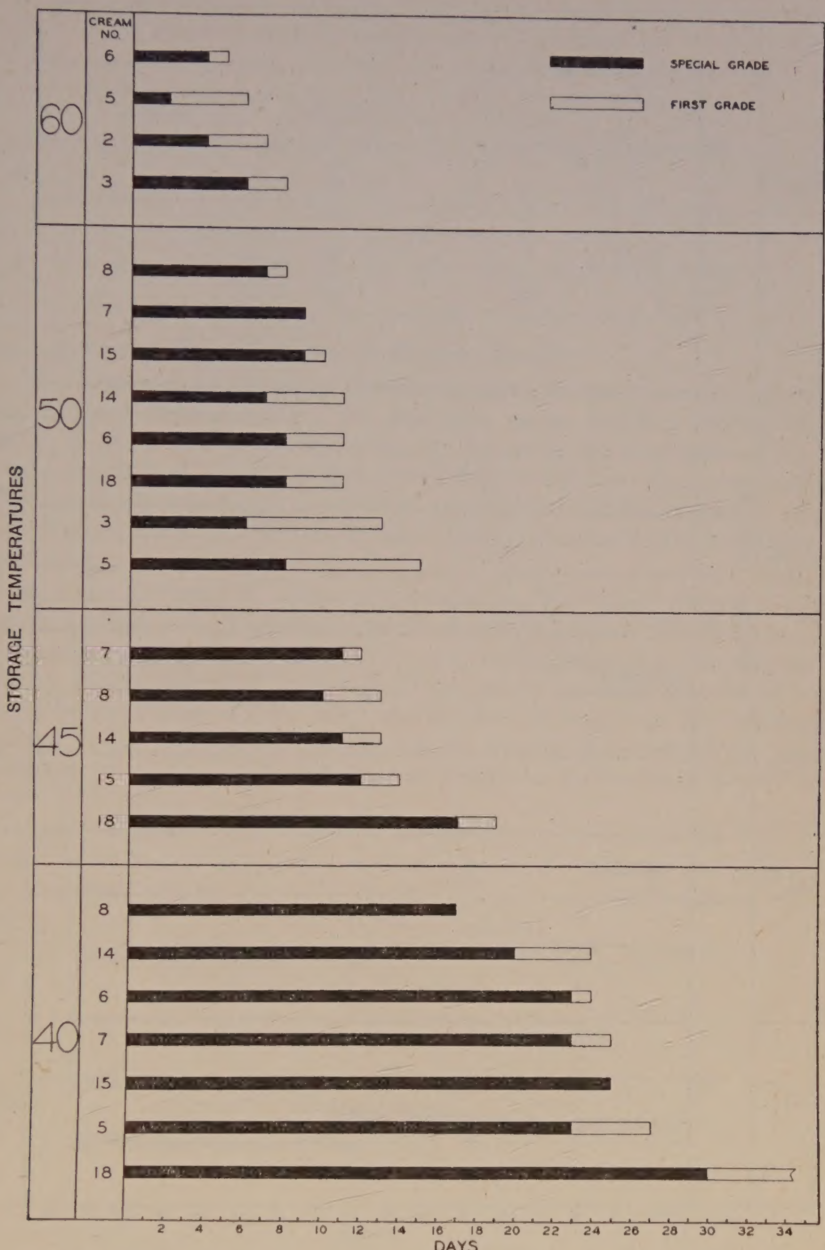

FIGURE 3. The number of days Farm A creams remained in Special and First Grades at various storage temperatures.

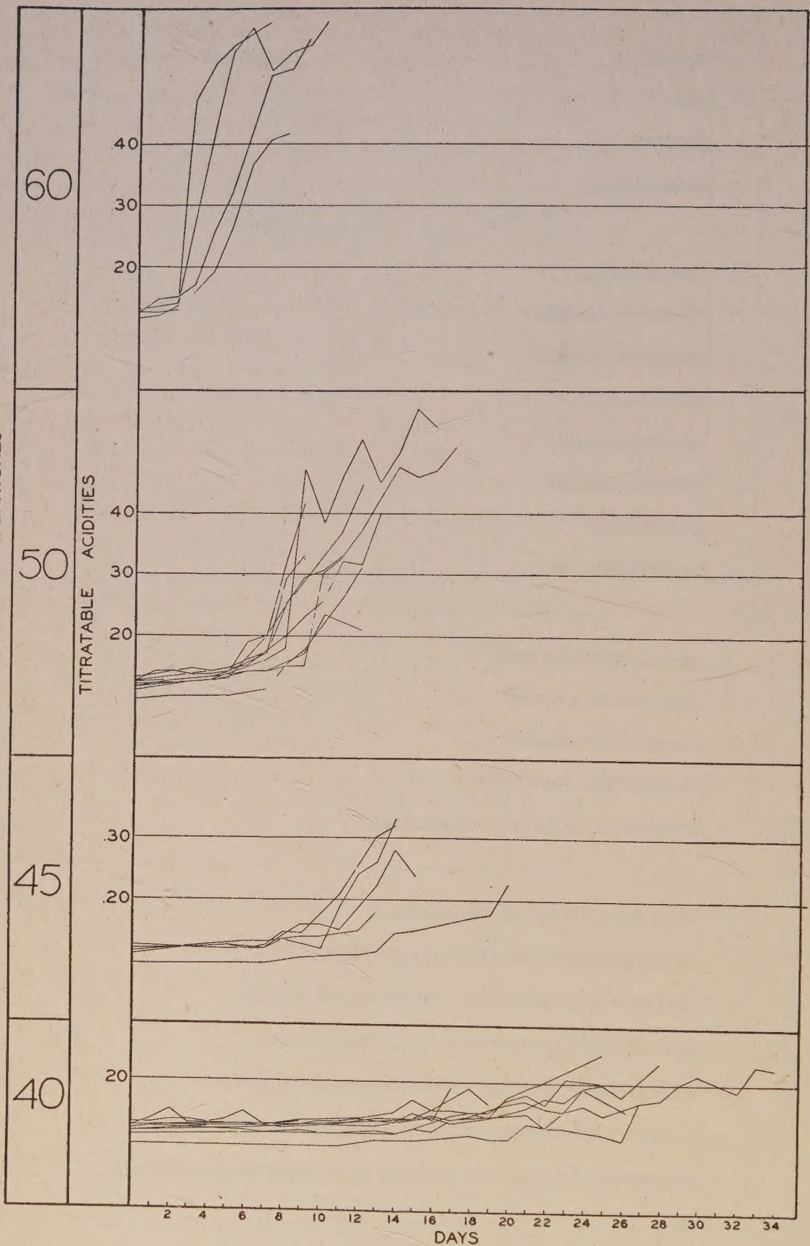

FIGURE 4. The titratable acidities of Farm A creams stored at various temperatures.

TABLE 3.—NUMBER OF DAYS FARM B CREAMS REMAINED IN SPECIAL AND FIRST GRADES AT VARIOUS STORAGE TEMPERATURES

Cream	Temperatures, ° F.	Special	First
20	50	2	5
	45	3	7
	40	2	5
21	50	7	8
	45	11	15
	40	26	26

The Influence of Transportation on Keeping Quality

The above data show the keeping quality of creams held at constant temperatures representative of practical farm holding temperatures. During summer transportation from the farms to the creameries churning creams are almost always subjected to higher surrounding temperatures. Laboratory reproduction of practical conditions is difficult but it is easy to subject experimental creams to conditions more severe than are necessary in practice.

For the purposes of this study it was assumed that there is rarely, if ever, a necessity to transport Alberta churning creams for 10 hours in a surrounding atmosphere over 80° F. A 3-gallon can, a 5-gallon can and an 8-gallon can of churning cream of 33 per cent butterfat content at initial temperatures below 45° F. were stored for 10 hours in an atmosphere between 80° F. and 85° F. These creams rose in temperature an average of slightly more than 2° F. per hour as shown in Table 4 and Figure 7.

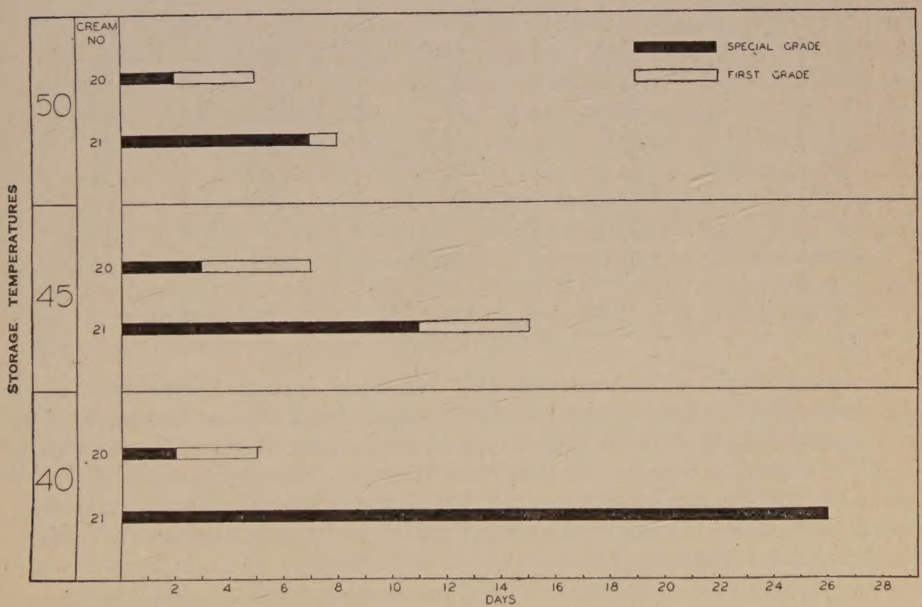

FIGURE 5. The number of days Farm B creams remained in Special and First Grades at various storage temperatures.

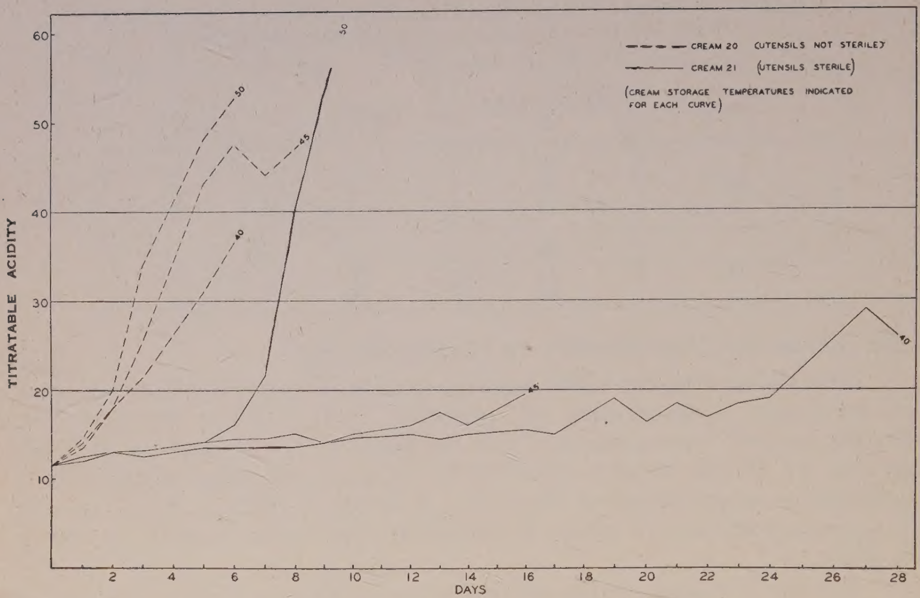

FIGURE 6. The titratable acidities of Farm B creams stored at various temperatures.

TABLE 4.—HOURLY TEMPERATURES OF CREAM HELD IN AN ATMOSPHERE ABOVE 80° F.

Time in hours	Temperatures in ° F.			
	3 Gallons	5 Gallons	8 Gallons	Atmosphere
0	42.5	41.0	42.0	82.5
1	48.0	46.0	45.5	85.0
2	52.0	50.0	49.5	83.5
3	54.5	52.0	52.0	81.5
4	57.0	55.0	54.5	82.5
5	59.0	57.0	56.0	82.5
6	60.5	59.0	57.5	81.5
7	62.0	60.0	59.0	82.0
8	63.5	61.5	60.5	82.0
9	64.5	62.5	62.0	82.5
10	66.0	64.0	63.0	83.5
Average increase /hour	2.35	2.3	2.1	

It is sometimes noticed that milk and cream held at low temperatures for long periods deteriorate rapidly at higher subsequent temperatures. To obtain information on this point, as related to transportation of high quality churning creams, creams from Farm A were held at 50° F. for 5 days, at 45° F. for 7 days and at 40° F. for 10 days. They were then incubated at 60° F. and 70° F. for ten hours and the grades and titratable acidities determined hourly as reported in Table 5.

It is seen that creams of this quality withstand rigorous treatment without serious deterioration. Therefore, creams of low bacterial content have an inherent "factor of safety" sufficient to maintain Special Grade on

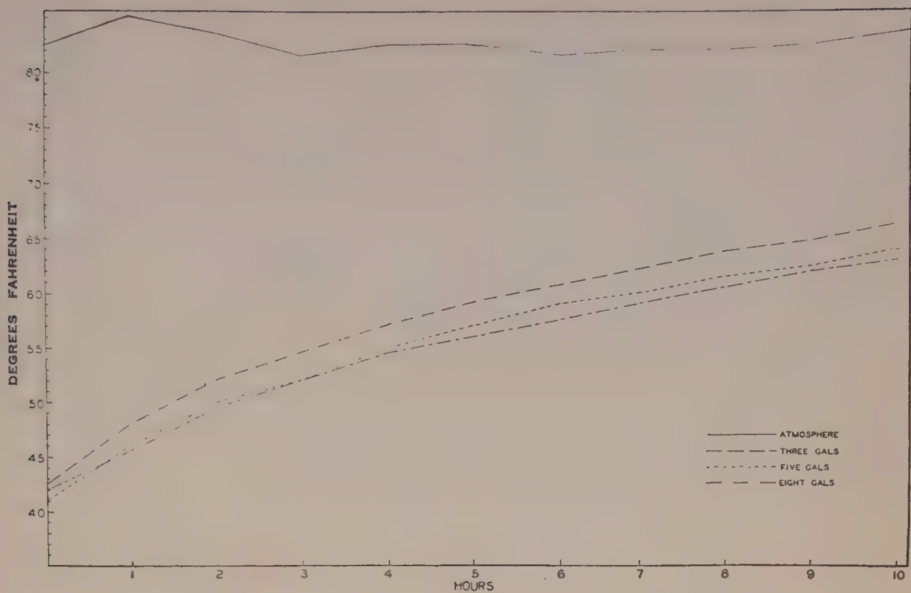

FIGURE 7. Temperatures of cream held in an atmosphere above 80° F.

delivery at the creamery twice weekly if stored at 50° F. and once weekly if stored at 45° F. or below, assuming reasonable care during transportation from the farm to the creamery.

Titratable Acidity

Titratable acidity as used in the dairy industry assumes that the only acid present in milk or cream is lactic acid. This assumption is probably never correct and the test is misleading in proportion to the kinds and amounts of other acids present. Lactic acid is present as the principal acid and in large amounts only as a result of the action of the lactic acid bacteria. In this area milk or cream of very low bacterial content contains few cells of lactic acid bacteria. This group appears to be introduced into the milk or cream in large numbers solely by non-sterile utensils. Temperatures below 50° F. are not favourable to the growth of these bacteria. On the other hand these low temperatures permit the growth of other species of bacteria some of which are acid forming but which produce little or no lactic acid, while some are non-acid forming.

The only criterion applicable in these studies for the differention of Table and Special Grade creams was titratable acidity. The titratable acidity of Table Grade cream must not be over 0.2 per cent. That titratable acidity had very limited value as a grading criterion of the creams of low bacterial content is illustrated by the fact that their grade deterioration from Special to First took place while the titratable acidities were below 0.20 (Figures 2, 4, 6). The degrading was on a basis of either non-acid flavour defects or in some cases non-lactic acid flavour defects. In many of the creams degrading was directly from Special to Second Grade, or First Grade was maintained for very short periods. It is apparent

TABLE 5.—EFFECT OF HIGHER SUBSEQUENT TEMPERATURES ON STORED CREAMS

Stored at	40° F. for 10 days				45° F. for 7 days				50° F. for 5 days			
Incubated at	60° F.		70° F.		60° F.		70° F.		60° F.		70° F.	
Hours	T.A.	Grade	T.A.	Grade	T.A.	Grade	T.A.	Grade	T.A.	Grade	T.A.	Grade
0	0.120	Special	0.120	Special	0.130	Special	0.130	Special	0.110	Special	0.110	Special
1	0.120	Special	0.125	Special	0.125	Special	0.130	Special	0.120	Special	0.130	Special
2	0.120	Special	0.125	Special	0.130	Special	0.125	Special	0.120	Special	0.125	Special
3	0.120	Special	0.130	Special	0.125	Special	0.130	Special	0.130	Special	0.130	Special
4	0.125	Special	0.130	Special	0.120	Special	0.140	Special	0.125	Special	0.125	Special
5	0.120	Special	0.135	Special	0.125	Special	0.125	Special	0.120	Special	0.140	Special
6	0.130	Special	0.140	Special	0.120	Special	0.160	Special	0.120	Special	0.145	Special
7	0.125	Special	0.140	Special	0.130	Special	0.145	Special	0.115	Special	0.150	Special
8	0.125	Special	0.145	Special	0.135	Special	0.135	Special	0.130	Special	0.145	Special
9	0.130	Special	0.160	Special	0.140	Special	0.145	Special	0.130	Special	0.145	Special
10	0.135	Special	0.170	Special	0.140	Special	0.150	Special	0.140	Special	0.150	Special

TABLE 6.—EFFECT OF PLATE INCUBATION TEMPERATURE ON THE PLATE COUNTS OF STORED CREAMS

Cream	Stored		Plate incubation temperatures					
	Days	Temperature	37° C., 2 days	25° C., 5 days	15.6° C., 7 days	10° C., 8 days	7.2° C., 11 days	4.5° C., 14 days
3	7	40° F.	2,750	70,000	>30,000			
3	7	50° F.	165,000,000	135,000,000	130,000,000			
5	8	40° F.	7,000	100,000	100,000			
5	8	50° F.	520,000,000	548,000,000	595,000,000			
18	15	40° F.	1,325,000	4,250,000		6,000,000	7,000,000	3,000,000
18	15	50° F.	49,000,000	73,500,000		78,000,000	68,000,000	8,500,000

that, as cream supplies improve and holding temperatures are lowered and holding periods lengthened, the titratable acidity test is destined to play a more limited role in cream control.

The fact that Special Grade cream commands the highest price paid for churning cream has led to considerable confusion in the common conception of the bacteriological condition of such cream. The standard for this Grade permits a titratable acidity up to 0.30. A cream of this acidity is sour to the taste and has a total bacterial content approaching the maximum number possible to grow in cream (Table 1). Judged by the criteria usual in the market milk industry, such a cream has long since passed into the rejectable class—it is "good" cream only in that it will churn into First Grade butter.

BACTERIOLOGICAL TESTS

Of the bacteriological tests used for the routine grading of raw fluid milks, the reduction tests are the simplest and most nearly fool-proof. No other test is sufficiently cheap for routine application to raw churning creams. The theoretical methylene blue reduction time of a milk is zero, or nearly so, when the milk contains about 100 million bacteria per ml. At the time a milk shows any increase in acidity measurable by the titratable acidity test, the bacterial content of the milk will approach 100 million cells per ml. It is seen that the time differentials are outside the scope of the reduction test by the time there is a measurable increase in acidity. The same relation probably holds approximately true for the various resazurin tests. Therefore, the reduction tests do not appear to have a routine place in the quality control of churning creams at the point of delivery.

The plate count is widely applied in the milk industry and, at first sight, might seem to be applicable to the problem under discussion here. But, apart from cost considerations, one factor alone complicates plate count results to the extent that much research would probably have to be done before adoption of the test is possible for this purpose. This complication arises because of the varying but long holding periods at low but varying temperatures in the churning cream industry. Assuming that there is one ideal medium for supporting bacterial growth—which there is not—there is still no single ideal temperature for incubation of the plates. This is illustrated by the data in Table 6.

But there appears to be no present purpose in the routine application of bacteriological tests to raw churning creams at the point of delivery. The highest official grade recognized for such cream is Special and specifications for this grade permit creams that are quite sour to the taste. By taste alone much finer differentiations are possible than are required by this grade standard. Differentiation by bacteriological tests will not be practical until very considerably higher flavour standards for butter are demanded by the public.

On the other hand this was an investigation of the growth of bacteria in creams held at low temperatures with acid production and flavour changes as the measures of such growth. It was deemed desirable to supplement these tests with the standard bacteriological techniques. Therefore, methylene blue reduction times and plate counts were determined daily for most of the creams throughout their storage periods.

The methylene blue reduction test was found to have very limited value because the reduction times were zero usually before there was any increase in titratable acidity and always long before the creams were degraded. This was despite the encouragement of a psychrophilic flora by low storage temperatures, while the test incubation temperature was 37° C. It may be that during the long storage there was considerable fixation of the oxygen dissolved in the cream. Nevertheless, no seriously anomalous results were observed and the reduction times of Farm A creams paralleled storage times and temperatures.

Plate counts of Farm A creams were found to be applicable throughout the entire grading period but there were many irregularities. In general the counts paralleled the storage times and temperatures. The daily reduction time and plate count curves for cream 18 are presented in Table 7. From Table 8 it will be noted that there is a tendency for the creams of low bacterial content stored at 40° F. to be degraded while the plate counts were still comparatively low. This is because degrading was not the result of the action of lactic acid bacteria. However, there can be no doubt that extensive bacterial growth took place in these creams at 40° F.

TABLE 7.—GROWTH OF BACTERIA IN CREAM 18 STORED AT VARIOUS TEMPERATURES

Days of storage	Storage temperatures					
	Plate counts			Reduction times (hours)		
	40° F.	45° F.	50° F.	40° F.	45° F.	50° F.
0	3,000	3,000	3,000	8¾	8¾	8¾
2	—	<4,000	<25,000	—	>4	>4
5	—	400,000	11,000,000	—	6	¾
7	11,800	8,600,000	69,000,000	>9	2¼	0
8	—	18,750,000	127,000,000	—	1½	
9	189,000	74,000,000	137,000,000	>4	¾	
11	362,000	62,000,000	459,000,000	9½	½	
12	—	58,000,000	510,000,000	—	0	
13	—	74,000,000		6		
14	1,550,000	240,000,000		4¼		
15	4,250,000	73,500,000		4		
18	46,000,000	220,000,000		1¼		
19	19,000,000	114,000,000		2		
20	72,000,000	23,650,000		0		
22	65,000,000					
25	104,000,000					
27	124,000,000					
29	187,000,000					
33	263,000,000					

TABLE 8.—PLATE COUNTS OF CREAMS ON THE LAST DAY ON WHICH THEY GRADED SPECIAL

Origin	Cream	Plate counts, Storage temperature, 40° F.	45° F.	50° F.
Farm A	5	154,000,000	—	70,000,000
	6	66,000,000	—	32,000,000
	7	26,000,000	79,000,000	206,000,000
	8	<20,000,000	70,000,000	350,000,000
	14	36,000,000	310,000,000	315,000,000
	15	66,000,000	300,000,000	510,000,000
	18	187,000,000	73,500,000	127,000,000
Plant	11	195,000,000	200,000,000	<600,000,000
	12	350,000,000	91,000,000	127,000,000
	13	200,000,000	—	—
	16	310,000,000	—	—
	17	320,000,000	219,000,000	410,000,000
	19	345,000,000	—	—

Types of Defects

Some creams had shortened keeping times because of the appearance of defects believed not to be caused by bacterial action. Oxidized flavours catalysed by dissolved metals from utensils in recognizably poor condition and rancid flavours may be mentioned. Such defects are not considered in this communication other than to state that, because of them, grades were sometimes lowered much sooner than would otherwise have been the case.

As was expected, there were encountered some bacterially-induced defects which are not common in commercial churning creams. As commercial creams are improved these defects are likely to become more prominent. Two such defects were sufficiently impressive to merit mention.

Many of the creams of low bacterial content stored for long periods at the lowest temperatures developed a strong bitterness suggestive, not of the peptones, fatty acids or aldehydes, but of the alkaloids. Isolations were made of short, gram negative rods capable of producing this defect markedly in skim milk at temperatures varying from 40° F. to 98.6° F.

A few creams lost grade because of a sharp acid flavour, although the titratable acidity was relatively low. This defect appeared to be more prevalent at the higher than at the lower storage temperatures.

SUMMARY AND CONCLUSIONS

1. Summer churning cream of low bacterial content at the time of production on the farm is achieved by the same procedure necessary for the production of market milk of low bacterial content. The most important step in this procedure is to permit the milk and cream to come into contact with only sterile surfaces. Therefore, *all* utensils must be sterilized.

2. Special Grade may be attained with twice weekly delivery when the storage temperature of cream of low bacterial content is 50° F., and with weekly delivery when the storage temperature is not over 45° F. Five degrees difference in storage temperature makes a marked difference in the keeping quality of the stored creams within the range of 40° F. to 50° F. These temperatures are attainable in the Edmonton area by the proper use of well-water as the coolant.

3. The long storage of such creams at temperatures of 50° F. or below will probably result in bacterially-induced flavour defects not now very common in the churning cream industry.

4. The titratable acidity test in these circumstances may become of very limited value as a differential criterion in grading. Frequently it is misleading.

5. The reduction test and the plate count do not appear to offer any advantages in the routine control of churning creams when applied at the point of delivery.

STUDIES WITH RAPE-SEED OILCAKE MEAL[1]

I. THE EFFECT OF VARIOUS LEVELS OF RAPE-SEED OILCAKE MEAL IN THE DIET ON THE WEIGHT OF THE THYROID GLANDS OF TURKEY POULTS

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Rape-seed oilcake meal has become an important by-product of the vegetable oil extraction industry in Canada. The 1946 rape-seed crop resulted in the production of 6,160,000 pounds of this by-product and it is estimated that the 1947 crop will produce approximately 8,000,000 pounds of the meal. This oilcake meal is being used in the manufacture of various classes of live stock and poultry feeds in Canada. Only a few references to the feeding value of rape-seed oilcake meal as a protein supplement are to be found in the literature. Pettit, Slinger *et al.* (5) tested various levels of rape-seed oilcake meal and reported that, while growth weights were somewhat depressed, rape-seed oilcake meal, at levels up to 14 per cent, was a satisfactory substitute for meat meal in a starting ration for baby chicks. These authors quoted the work of Fanguaf and Haensel (3). The senior author, in 1946, tested the value of rape-seed oilcake meal in the finishing of 19½ week-old bronze turkeys over a 40-day period and reported[4] that the group fed rape-seed oilcake meal was unable to withstand a sudden drop in temperature as well as the group on standard growing mash containing commercial meat meal. Turkey hens fed standard ration were .15 pounds and .76 pounds heavier at 30 days and 40 days, respectively, than the rape-seed meal group. Toms fed standard ration were .84 pounds and 1.79 pounds heavier for the same periods. The onset of severe weather occurred during the last 10 days of the test. There was only a slight advantage in favour of the standard ration group in the finish of the dressed carcasses. The number of birds slaughtered, however, was too small to make these latter results significant. The possibility was suggested that the goiterogenic properties of the whole rape-seed, reported in 1941 by Kennedy and Purves (4), may be concentrated in the meal by-product and may have interfered with the heat regulatory mechanism of the birds. Schultze and Turner (8) reported that goiterogenic substances can produce such an effect.

Numerous authors have used the criterion of increased thyroid size as one indication of the activity of a goiterogenic agent in the diet of both poultry and live stock. These include Schultze and Turner (8), Reineke *et al.* (7), Andrews and Schnetzler (1, 2), Turner (9, 10) and Kennedy and Purves (4).

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[1] Contribution from the Poultry Division, Dominion Experimental Farms Service, Canada.
[2] Officer-in-Charge, Poultry.
[3] Student Assistant, Poultry.
[4] Annual Report, Dominion Experimental Station, Swift Current, Sask. 1946. (Unpublished).

EXPERIMENTAL METHODS

To test the possible goiterogenic properties of rape-seed oilcake meal an experiment was started in the spring of 1947. Day-old turkey poults were randomized throughout the compartments of an electrically heated battery brooder. This brooder was located in a room in which the temperature was thermostatically controlled. Throughout the first three weeks of the test the room temperature ranged from 75° F. to 85° F. During the last four weeks of the test the birds were transferred to unheated growing batteries in a room held at 75° F. to 80° F.

The basic ration used is given in Table 1 and the experimental rations are shown in Table 2.

TABLE 1.—BASAL RATION

Ingredient	Weight	Ingredient	Weight
	lb.		lb.
Ground wheat	20	Milk powder	5
Ground oat groats	10	Fine salt (iodized)	1
Pulverized whole oats	5	Fish oil (200D)	1
Wheat bran	5	Manganese sulphate	11.3 gm.
Alfalfa meal	6.5	Riboflavin	0.2 gm.
Vita grass	3.5		
Fish meal	12	TOTAL	69

TABLE 2.—EXPERIMENTAL RATIONS

Ration No.	Basic	Rape-seed meal*	Meat meal 50% protein	Ground limestone	Steamed bone meal	Ground barley
	%	%	%	%	%	%
6	69	0.00	15.00	1.00	—	15.00
6B	69	4.00	12.00	1.60	0.30	13.10
6E	69	10.00	7.50	1.70	1.60	10.20
6J	69	20.00	—	2.40	3.25	5.35

* Rape-seed oilcake meal obtained through the courtesy of Prairie Vegetable Oils Limited, Moose Jaw, Saskatchewan.

The figures used for the chemical analysis of the rape-seed oilcake meal were the average from two separate analyses made by the Chemistry Division, University of Saskatchewan, and the Chemistry Division, Science Service, Department of Agriculture, Ottawa. These analyses showed a protein content of 37.5 per cent. As the per cent of rape-seed meal in the rations was increased, the per cent of meat meal was reduced accordingly to maintain a uniform calculated protein content. It was necessary also to adjust the steamed bone meal and ground limestone contents of the ration to maintain a uniform calculated calcium and phosphorus level. Further differences in the total amounts of the rations were adjusted by the addition of lesser amounts of ground barley.

The test was conducted for a 42-day period. At the conclusion of the test, 10 birds were selected at random from each of the lots which had been fed 4 per cent, 10 per cent and 20 per cent of rape-seed oilcake meal

as well as from the controls. These birds were slaughtered and their thyroid glands removed and weighed on an analytical balance. The thyroid weights are presented in Table 3.

TABLE 3.—THYROID WEIGHTS FROM 42-DAY-OLD TURKEY POULTS FED VARYING LEVELS OF RAPE-SEED OILCAKE MEAL

Ration No.	No. poults	Average weight	Average thyroid weight	Thyroid weight per 100 gm. B.W.
		gm.	mg.	mg.
6	10	783.7	52.72	6.72
6B	10	655.9	89.60	13.66
6E	10	752.2	162.51	21.60
6J	10	721.7	262.62	32.23

From a study of Table 3 it can be seen that the birds on ration No. 6, receiving no rape-seed oilcake meal, had thyroid weights of 6.72 milligrams per 100 grams body weight, while those on rations 6B (4 per cent rape-seed meal), 6E (10 per cent rape-seed meal) and 6J (20 per cent rape-seed meal) had thyroid weights of 13.66 milligrams, 21.60 milligrams and 32.23 milligrams per 100 grams of body weight. Four per cent of rape-seed meal increased thyroid weight more than twice, while 10 per cent and 20 per cent increased thyroid weight by 3.2 times and 4.8 times that of the control birds.

DISCUSSION

Schultze and Turner (8) discussed goiterogenic agents in considerable detail. They classed them into two groups one of which is prevented by increased iodine intake and one which is not. The goiterogenic effect of whole ground rape-seed on the thyroid glands of rats was classed in the latter group. Purves (6) showed that the goiterogenic effect produced by the feeding of Brassica seeds to rats acted on the thyroxine secreting mechanism of the thyroid in a manner comparable to thiourea and thiouracil rather than as soybeans or cabbage leaves.

Simultaneously with the planning of the present experiment, a sample of the rape-seed oilcake meal to be used was submitted to Dr. C. W. Turner, Missouri State College, Columbia, Missouri. Turner[1] reported that when this meal was included in the diets of day old chicks at levels of 10 per cent, 20 per cent, 30 per cent and 40 per cent, it produced thyroid weights of 24.75 milligrams, 36.22 milligrams, 48.49 milligrams and 55.85 milligrams per 100 grams of body weight as compared to the control chicks which had thyroids weighing 6.79 milligrams per 100 grams body weight. Turner[1] concludes from his work with whole ground rape-seed (9), that the entire goiterogenic properties of whole rape-seed are concentrated in this meal. This same worker attempted to overcome the goiterogenic properties of this feedstuff by increasing iodine intake and found that KI fed at levels as high as 36 milligrams per kilogram of feed failed to reduce thyroid size to normal when 40 per cent of rape-seed oilcake meal was included in the diet.

[1] Personal correspondence.

A study of the effect of goiterogenic agents on body functions would indicate that rape-seed oilcake meal fed at least at the higher levels would be expected to produce a reduction in basic metabolic rate, a lowered feed intake, lower weight gains and increased fattening. At these levels it might also be expected to interfere with the heat regulatory mechanism of the bird's body during the sudden onset of severely cold weather. It is suggested that rape-seed oilcake meal may be more suitable as a component of fattening and finishing rations than of starting and growing rations. These data indicate that the value of rape-seed oilcake meal in the diets of live stock and poultry needs to be further investigated.

SUMMARY AND CONCLUSIONS

Rape-seed oilcake meal at levels of 4 per cent, 10 per cent and 20 per cent was included in the diet of turkey poults for a 42-day period. Thyroid enlargement was noted for all groups fed rape-seed oilcake meal. Increases of 2, 3.2 and 4.8 times that of the thyroid weight of the controls were obtained on rations containing 4 per cent, 10 per cent and 20 per cent of rape-seed oilcake meal.

Similar results were obtained by C. W. Turner, Missouri State College, when this same rape-seed meal was fed to baby chicks. Increases of 3.6, 5.3, 7.1 and 8.2 times the thyroid weight of the controls were obtained by feeding 10 per cent, 20 per cent, 30 per cent and 40 per cent of rape-seed oilcake meal in the starting diet of the baby chicks. Turner[1] concludes that the entire goiterogenic properties of whole rape-seed are concentrated in the meal.

It is suggested that rape-seed oilcake meal may be more suitable for fattening and finishing diets than for starting and growing rations. The whole problem of the value of rape-seed oilcake meal in live stock feeding and its effect on body functions needs to be further investigated.

ACKNOWLEDGMENTS

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REFERENCES

1. Andrews, F. N., and E. E. Schnetzler. Influence of thiouracil on growth and fattening in broilers. Poultry Science 25 : 124-129. 1946.
2. Andrews, F. N., and E. E. Schnetzler. The effect of feeding thiouracil to hens upon the thyroid glands of chicks. Endocrinology 37 : 382-384. 1945.
3. Fangauf, R., and A. Haensel. Rye bran, dried brewers' grains, malt combs and ground rape-seed cake for hens. Archive Geflugells 12 : 149-150. 1938.
4. Kennedy, T. H., and H. D. Purves. The effect of brassica seed diets on rats. Brit. Jour. Exper. Path. 22 : 241. 1941.
5. Pettit, J. H., S. J. Slinger, *et al.* The utilization of sunflower seed oil meal, wheat distillers' dried grains and rape-seed oil meal in poultry rations. Sci. Agr. 24 : 201-213. 1944.

[1] Personal correspondence.

REFERENCES—Concluded

6. Purves, H. D. Studies on experimental goitre. IV. The effect of diiodotyrosine and thyroxine on the goiterogenic action of brassica seed. Brit. Jour. Exper. Path. 24 : 171-173. 1943.
7. Reineke, E. P., *et al.* The effect of thiouracil on fattening turkeys. Poultry Science 25 : No. 4. 1946. (Abstract only).
8. Schultze, A. B., and C. W. Turner. The determination of the rate of thyroxine secretion by certain domestic animals. Mo. Agr. Exp. Sta. Res. Bull. 392. 1945.
9. Turner, C. W. The effect of rape-seed on the thyroid of the chick. Poultry Science 25 : 186-187. 1948.
10. Turner, C. W. The effect of thiobarbital and thiouracil on the thyroid. Poultry Science 25 : 51 7-520. 1946.

STUDIES WITH RAPE-SEED OILCAKE MEAL[1]

II. THE EFFECT OF THE INCLUSION OF PROTAMONE IN THE DIET, ON THE THYROID ENLARGEMENT INDUCED BY THE FEEDING OF RAPE-SEED OILCAKE MEAL TO TURKEY POULTS

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Studies on the effect of including rape-seed oilcake meal in the diet of turkey poults in this laboratory indicated that this protein supplement possessed a goiterogenic property which resulted in considerable thyroid enlargement (2). Further studies were undertaken to obtain additional data on the feeding value of this protein supplement and to test the possibility of counteracting the goiterogenic properties of rape-seed oil meal by the inclusion of Protamone in the diet.

Mixner, Reineke and Turner (5) and Schultze and Turner (7) showed that graded doses of thyroxine injected subcutaneously could be used to counteract the goiterogenic effect induced by the feeding of 0.1 per cent thiouracil to chicks and that the enlarged thyroid glands could be reduced in size to normal or smaller by increasing the thyroxine dosage. Protamone contains approximately 3 per cent thyroxine.

EXPERIMENTAL METHODS

Ninety bronze turkey poults, which were 15 days of age, were randomized into three equal groups which were placed in separate compartments of an electrically heated battery brooder. At the age of 28 days they were transferred to the compartments of an unheated growing battery in a room in which the temperature varied from 70° to 85° F.

The rations used in this test are given in Table 1.

Table 1.—Experimental rations

Ration No.	Basal	Rape-seed meal*	Meat meal 50% protein	Ground limestone	Steamed bone meal	Ground barley	Protamone**
	%	%	%	%	%	%	
6	69	0.00	15.00	1.00	—	15.00	
6J	69	20.00	—	2.40	3.25	5.35	
6K	69	20.00	—	2.40	3.25	5.35	36 gm./100 lb.

* Rape-seed oilcake meal obtained through the courtesy of Prairie Vegetable Oils Limited, Moose Jaw, Saskatchewan.
** Protamone obtained through courtesy of Cerophyll Laboratories, Kansas City, Missouri.

Group No. 1 received the basal ration (Ration No. 6). Group No. 2 received a ration in which the meat meal was replaced with 20 per cent rape-seed oil meal (Ration No. 6J). Group No. 3 received the same ration as Group No. 2 with the addition of 36 grams of Protamone per

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100 pounds (Ration No. 6K). The basal ration used is given in Table 2. The differences in the per cent of rape-seed oil meal and meat meal used in these rations were necessary in order to equalize the calculated protein content between groups. Further differences in the total amounts of the rations were adjusted by the addition of lesser amounts of ground barley.

TABLE 2.—BASAL RATION

Ingredient	Weight	Ingredient	Weight
	lb.		lb.
Ground wheat	20	Milk powder	5
Ground oat groats	10	Fine salt (iodized)	1
Pulverized whole oats	5	Fish oil (200D)	1
Wheat bran	5	Manganese sulphate	11.3 gm.
Alfalfa meal	6.5	Riboflavin	0.2 gm.
Vita grass	3.5		
Fish meal	12	TOTAL	69

Weekly body weights and feed consumption data were recorded. In addition, the incidence of perosis and dermatitis as well as other obvious nutritional deficiencies were noted.

Birds were maintained on the experimental rations for a 35-day period. At the conclusion of the test, 15 birds were selected at random from each group. These were slaughtered and the thyroid glands were removed and weighed on an analytical balance.

RESULTS AND DISCUSSION

Table 3 presents the data for final body weights and feed consumption per bird.

TABLE 3.—BODY WEIGHTS AND FEED CONSUMPTION FROM TURKEY POULTS FED RAPE-SEED OIL MEAL AND RAPE-SEED OIL MEAL PROTAMONE DIETS

Group No.	Ration No.	No. of surviving poults	Mortality	Body weight	Feed consumption/bird
				lb.	lb.
1	6	21	9*	2.24	3.162
2	6J	25	5**	1.85	4.030
3	6K	28	2***	2.11	4.854

* Four removed due to perosis, 3 injured in battery and 2 cause unknown.
** Three injured in battery, 1 removed for perosis and 1 cause unknown.
*** Removed due to perosis.

The poults on Ration No. 6 (Controls) averaged 2.24 pounds; those on Ration No. 6J (20 per cent rape-seed oil meal) 1.85 pounds, and those on Ration No. 6K (Ration No. 6J + 36 grams Protamone per 100 pounds) 2.11 pounds. While further investigations may be necessary to confirm these findings, there is strong evidence to show that the addition of Protamone to rape-seed oil meal rations is capable of inducing more nearly normal growth than the rape-seed oil meal without the addition of Pro-

tamone. The addition of 36 grams of Protamone per 100 pounds of feed to Ration 6J gave a 14.05 per cent increase in body weight. This difference is statistically significant. It will be noted from Table 4 that the thyroid weights for Group 3, which were fed Ration 6K, are recorded for only five birds. In the case of five additional birds, it was only possible with our technique to remove and weigh one thyroid gland, because of the exceptionally small size. In the case of the remaining five birds, the thyroid glands were so small as to make it impractical to remove and weigh them. The thyroid weight picture for Group 3 as presented in Table 4, therefore, does not give an entirely true indication of the reduction in size effected by the addition of 36 grams of Protamone per 100 pounds of feed. The average was actually much lower than shown. The data presented here, however, do give a definite indication of the effect of Protamone in counteracting the goiterogenic properties of rape-seed oilcake meal.

Table 4.—The effect on thyroid weight of the addition of 36 grams of protamone per 100 pounds of feed to a rape-seed oil meal diet

Group No.	Ration No.	No. birds	Mean B.W.	Mean thyroid weight	Thyroid weight per 100 gm. B.W.
			gm.	mg.	mg.
1	6	15	975.06	66.00	7.76
2	6J	15	827.46	202.18	24.43
3	6K	5*	887.80	6.92	0.78

* Data from only five birds from which it was possible to dissect and weigh both thyroids.

No data are to be found in the literature on the natural thyroxine secretion rate of the thyroid glands of turkey poults. It is evident from this test, however, that 36 grams of Protamone per 100 pounds of feed are not only capable of counteracting the goiterogenic effect of 20 per cent of rape-seed oil meal, but are capable of supplying sufficient thyroxine, in addition, to cause a regression in the size of the thyroid gland to considerably below normal size, when fed over a 35-day period. Further investigations will be necessary to determine more accurately the amount of Protamone required to reduce to normal size the thyroid enlargement induced by the feeding of various levels of rape-seed oil meal in the diet.

This test produced further interesting data on the possible feeding value of rape-seed oil meal. It will be seen from Table 5 that the incidence of perosis in the control group (Ration No. 6) was six moderate to severe cases, while Rations 6J and 6K showed only one and two moderate cases, respectively. Eight cases of moderate to severe dermatitis were recorded for Ration 6 while no dermatitis was evident from Ration 6J or 6K. Typical lesions of the mouth and eyes and cracking of the soles of the feet were noted in the eight cases on Ration 6. Dermatitis was prevalent in the control birds as early as the fourteenth day of the test. A lysine deficiency also showed up as this test progressed. This was indicted by excessive white in the wing feathers of the poults. Approximately two-thirds of the poults in the control group showed this deficiency while on the other hand it was only very slightly evident in the groups on the rape-seed oil meal

diets. No data are available in the literature on the lysine content of rape-seed oilcake meal. The evidence here presented would indicate that this is a question that may well be investigated.

TABLE 5.—INCIDENCE OF PEROSIS, DERMATITIS AND DEGREE OF LYSINE DEFICIENCY IN TURKEY POULTS FED A RAPE-SEED OIL MEAL DIET AND A RAPE-SEED OIL MEAL PROTAMONE DIET

Group No.	Ration No.	No. of birds in test	No. of cases perosis	No. of cases dermatitis	Degree of lysine deficiency
1	6	30	6	8	Moderate
2	6J	30	1	—	Slight
3	6K	30	2	—	Slight

Rape-seed oil meal appears to lack palatability when fed to many forms of live stock. No difficulty was experienced, however, in inducing poults to consume it when it was mixed in a starter ration.

Kempster and Turner (3), Mixner, Tower and Upp (4), and Andrews and Schnetzler (1) reported on the feeding of thiouracil to broilers and cockerels; Reineke *et al.* (6) and Blakely[1] reported on the effect of the feeding of thiouracil to turkeys. Goiterogenic agents such as thiouracil when included in the diets of broiler chickens, cockerels and semi-mature market turkeys were shown to improve fattening and finish. The results with turkeys are by no means complete, but those with broiler chickens are much more so. Our results would indicate that high levels of rape-seed oil meal in the diet may be capable of producing the same thyroid enlargement in turkey poults as 0.1 per cent thiouracil.

SUMMARY AND CONCLUSIONS

Three groups of thirty, 15-day-old turkey poults were placed on a basal starter mash and on a starter mash containing 20 per cent rape-seed oil meal and 20 per cent rape-seed oil meal plus 36 grams of Protamone per 100 pounds of feed.

Thyroid weight in the rape-seed oil meal group was 3.1 times that of the control group. The addition of 36 grams of Protamone per 100 pounds of feed to the rape-seed oil meal ration reduced the thyroid size to approximately one-tenth that of the controls. The amount of Protamone required to counteract the goiterogenic properties of 20 per cent rape-seed oil meal in the diet is considerably below 36 grams per 100 pounds.

Protamone, when added to a rape-seed oil meal diet, under the conditions of this experiment, induced growth more nearly normal than rape-seed oil meal without the addition of Protamone.

Rape-seed oil meal at levels of 20 per cent in the diet of growing poults, either with or without the addition of Protamone, resulted in a lower incidence of perosis and no indication of dermatitis; whereas the control group, with meat meal in the diet, resulted in six cases of perosis and eight cases of dermatitis. Lysine deficiency was much more prevalent in the control group.

[1] Annual Report, Dominion Experimental Station, Swift Current, Sask. 1946. (Unpublished).

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REFERENCES

1. Andrews, F. N., and E. E. Schnetzler. Influence of thiouracil on growth and fattening in broilers. Poultry Science 25 : 124-129. 1946.
2. Blakely, R. M., and R. W. Anderson. Studies with rape-seed oilcake meal. I. The effect of various levels of rape-seed oilcake meal in the diet on the weight of the thyroid glands of turkey poults. Sci. Agr. 28 : 393-397. 1948.
3. Kempster, H. L., and C. W. Turner. The effect of feeding thiouracil on the fleshing of New Hampshire broilers. Poultry Science 24 : 94-96. 1945.
4. Mixner, J. P., B. A. Tower, and C. W. Upp. The effect of feeding thiouracil on body weight of New Hampshire cockerels. Poultry Science 25 : 536-538. 1946.
5. Mixner, J. P., E. P. Reineke, and C. W. Turner. Effect of thiouracil and thiourea on the thyroid glands of chicks. Endocrinology 34 : 168-174. 1944.
6. Reineke, E. P., *et al.* The effect of thiouracil on fattening turkeys. Poultry Science 25 : No. 4. 1946. (Abstract only).
7. Schultze, A. B., and C. W. Turner. The determination of the rate of thyroxine secretion by certain domestic animals. Mo. Agr. Exp. Sta. Res. Bull. 392. 1945.

THE DISTRIBUTION, LIFE-HISTORY AND CONTROL OF *PHYLLOPHAGA ANXIA* LEC. IN QUEBEC AND ONTARIO[1]

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INTRODUCTION

"White grubs," the larvae of June beetles (*Phyllophaga* spp.) have long been recognized as an agricultural problem in Eastern Canada, particularly in southern Quebec and Ontario. Early reports did not attempt to differentiate between species. The complicated life-history and the existence of "broods" were not known at that time. Recent investigations indicate that probably most of these references to white grubs deal with *Phyllophaga anxia* Lec.

HISTORY

Perhaps the first comprehensive and detailed report of white grub damage from Quebec was that of Dupont (4) in 1853 which referred to very serious damage to grain and other crops in Kamouraska and St. Maurice counties along the lower St. Lawrence. At both points losses to a wide range of farm crops were reported as being very severe.

For long periods afterwards reports of white grubs and their injuries were relatively few; nevertheless it is reasonable to expect that many actual outbreaks occurred which were neither recognized nor reported in literature. In 1910 Swaine (33) reported white grubs at the western extremity of Jacques-Cartier County. In 1923 Maheux (25) mentioned serious white grub damage from various parts of Quebec.

In 1924, the writer started detailed studies on white grubs at the Hemmingford Laboratory under the direction of C. E. Petch and both during 1924 and 1925 Petch and Hammond prepared reports (28, 29) on the natural enemies of white grubs and June beetles over southern Quebec, together with many facts relative to their general life-history and economic status. Further study indicated that the typical life-history period throughout the province was three years, and three separate life-cycle rhythms were found, each covering a separate geographical area. From large-scale collections of bettles and white grubs in the various areas it was apparent that the dominant species in Quebec was *P. anxia* Lec., with other species of the genus appearing only occasionally.

Some time later the Provincial Entomologist for Quebec, Georges Maheux, became interested in white grubs in the province and started active research on these pests.

The early history of white grubs in Ontario was found to have many characteristics in common with that of Quebec. There was the same confusion regarding duration of life-cycle, life-history, range and feeding habits. At the same time the economic status of these pests of agricultural crops was greatly understated.

[1] Contribution No. 2544, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

James Fletcher (6) in 1879 referred to common white grubs as "the worst pests in the world." The statement was doubtless founded upon many unpublished observations in Ontario and elsewhere. Twenty-six years later, in 1905, C. J. S. Bethune (1) reported white grubs as very injurious in the London district, with a number of species involved. J. D. Evans (5) in 1908 mentioned white grubs of various species as very destructive to crops in the Trenton area and also in Prince Edward County. A few years later Arthur Gibson (9) started intensive research on white grubs in the Ottawa district. He mentioned particularly a serious outbreak of white grubs in the district during 1912, possibly the first definite record from extreme eastern Ontario.

Further progress was made on detailed studies in Ontario by H. F. Hudson (24) who issued a report on the June beetles and white grubs of the Strathroy district (near London) during 1919. Hudson found that the four or five dominant species present all had a three-year life-cycle. After a study of white grubs in Quebec in the period of 1924-30 the investigations were carried on in Glengarry County in eastern Ontario where a severe outbreak of *P. anxia* was in progress. By expanding white grub surveys to the westward over Ontario it was learned that the zone of severe outbreak extended at least as far as Grenville County. With a major beetle flight in progress during 1935, surveys were continued toward Lake Huron. A similar life-cycle was found throughout, with very definite concentrations in the central part of Hastings County, on the south side of Lake Simcoe, in the Guelph area and at intervals throughout western Ontario. An outbreak in the Oshawa-Toronto, Niagara Peninsula and Lambton County areas, with a similar life-history rhythm to that found in southern Quebec, has been discovered and delineated in recent years.

ECONOMIC IMPORTANCE

Because of the scarcity of early records of the occurrence of white grubs and June beetles, one might be led to believe that these pests were of recent introduction and had suddenly become destructive to agricultural crops. However, the genus *Phyllophaga* is native to America and it is probable that white grubs have been present ever since farming began. It is also possible that early symptoms of white grub injuries to crops were considered as "a soil condition" or just "drought"; and few estimates were made of monetary losses. In the light of recent knowledge concerning white grubs it is apparent that they must have extracted a heavy toll from farmers, particularly during the latter part of the last century.

Maheux (26) surveyed infested farms in the Eastern Townships of Quebec during the outbreak of 1938 and found that grubs caused an average loss of $100 per farm for a total of over 75 farms. Since the survey covered only a small part of the total area of significant infestation in the province, a total crop loss of more than $250,000 would be a conservative estimate. The author (11) found an even higher average loss per farm in Glengarry and adjoining counties during 1933. Grub attack was so severe during that year that the fodder corn crop was virtually wiped out in some districts and thousands of acres of pasture were left almost bare. The same severe infestation actually occurred as far eastward as Smiths Falls and possibly

further. Out of a total of 800 acres of rough, boulder-strewn pasture land at Stoco, 400 acres were destroyed by white grubs during 1938. Thousands of acres with similar damage were observed over contiguous areas during the same year and the total actual loss must have attained a very large figure. During 1944 a white grub outbreak in the Niagara Peninsula cost the area over $250,000 in crop and nursery stock, not considering losses of a secondary nature. The recorded losses in the areas from eastern to western Ontario during the outbreak years from 1936 to the present date have not been totalled.

In estimating white grub losses it has been the custom to estimate on the basis of only the one year when second-year grubs occurred. This basis is accurate for annual crops but in pastures, which often constitute the largest area in one crop in the district, the effect may carry over for two or more years in the form of pasture grass destruction, soil erosion, noxious weed development and spread. In addition, the defoliation of trees by a major flight of June beetles causes significant damage which is difficult to evaluate on a monetary basis.

With a larger number of trained entomologists reporting damage from soil-inhabiting pests, life-histories better known, and the addition of wider surveys, recent reports of white grub damage have been more inclusive and much more accurate than was formerly possible. An estimate of $500,000 is not an excessive figure for the annual losses caused by white grubs from Manitoba to the Maritimes.

SYNONYMY

The June beetle *Phyllophaga anxia* Lec. was known as *Lachnosterna anxia* Lec., *Ancylonycha brevicollis* Blanchard and *A. puncticollis* Blanchard during 1850. Three years later it was known as *P. anxia* Melsheimer but during 1855 it was again moved into the genus *Ancylonycha* The next year it was included under *Lachnosterna* and, except during 1866, remained in that genus until 1916 when Glasgow established the validity of *Phyllophaga anxia* Lec. However, over a long period of Canadian entomological history the name *Lachnosterna dubia* Smith was used.

DISTRIBUTION

Of the 25 or more species of *Phyllophaga* known to occur in Canada, *P. anxia* has undoubtedly the widest and most general distribution. It has been recorded from every province and also from Newfoundland, Labrador, and certain areas of the Northwest Territories. Over this extensive range the species is capable of surviving, even under rather extreme conditions, including some areas with permanently-frozen subsoil. Of all the members of the genus *Phyllophaga* this species has the most northerly distribution, often far beyond the recognized limits of agriculture.

Characteristics of Infested Areas

All of the severe, continuous infestations of *P. anxia* in Eastern Canada occur in areas of rolling topography with relatively light soil. Such soils are fairly well drained and are more or less optimum for white grub habitation. The greatest concentrations of white grubs are found over the

middle or upper areas of slopes. Light or spotty infestations are found in the lowlands or valleys where the soil is often heavier and contains considerable moisture and colloidal matter. However, well-drained soils varying widely in type may have some heavy concentrations of white grubs. In planning rotations and crop planting to avoid injury to susceptible crops the soil type must be considered.

Flood plains and bottom lands, valleys or other low-lying areas containing one of the heavier types of soil may have a light or spotty infestation usually located in small "islands" of one of the lighter surface soils. June beetle damage over such areas will seldom be significant, with foliage injury confined to single leaves or twigs of favourite food species.

The distribution of white grubs and the intensity of infestations in an "outbreak season" as affected by soil types is shown in Table 1.

TABLE 1.—INFESTATION OF GRUBS AND PROBABLE CROP DAMAGE AS RELATED TO SOIL TYPES

Infestation	Grubs per sq. yd.	Soil type	Damage prospect
1. Light (spotty)	1-10	Clay (heavy)	Occasional injured plants.
2. Moderate	11-40	Clay loam	Spotty injury in pastures; slight injury to corn, potatoes.
3. Heavy	41-75	Sandy soil silt loam	Pastures seriously damaged; corn, potato injury general; grains slightly damaged.
4. Severe	76-150	Sandy loam	Pastures, corn, potatoes generally destroyed; serious injury to grain; slight injury to clover.

LIFE-HISTORY AND SEASONAL HISTORY

Phyllophaga anxia Lec. requires three years to complete its life-history. The adult beetles begin to emerge from the soil during the second week in May and reach their maximum abundance in early June. They begin laying eggs towards the end of May in areas of sod or grass-type vegetation. The eggs hatch in about 30 days and the first instar grubs start feeding on the roots of the surrounding vegetation. In from 6 to 8 weeks they moult into the second instar. After a short period of feeding, the second instar grubs burrow into the soil at varying depths where they remain inactive during the first winter.

As the soil begins to warm up in the spring, the second instar grubs move up to within 2 or 3 inches of the soil surface and feed ravenously on the roots and underground stems of a wide variety of plants. In late July a second moult occurs and the third instar grubs appear. These larger grubs feed for a short time and then burrow into the soil, some going as deep as 3 feet, where they spend the second winter.

The third instar grubs are mostly inactive in the spring. They do very little feeding and about July 15 begin to pupate. In the late summer, the beetles emerge from the pupae but remain inactive in the soil until the following spring

The duration of the different stages as observed over several years is shown in Table 2.

TABLE 2

Stage	First appearance	Maximum abundance	Last appearance	Individual period (days, approx.)
Adult beetle (active)	May 10	June 1-10	Early July	30
Eggs	May 24	June 25	Late July	30
First instar grubs	Late June	Aug. 5	October	50
Second ins. grubs	Early Aug.	Sept. 25	—	Wintering form
Second ins. (2nd year)	—	—	July 20	300 days
Third ins. (2nd year)	June 20	July 15	—	Wintering form
Third ins. (3rd year) (active)	June	July 7	July 15	—
Third ins. (inactive)	July 8	July 15	Aug. 10	360
Pupae	July 15	Aug. 5	Sept. 5	36
June beetle (inactive)	Aug. 5	Aug. 20	—	Wintering form (289)
				1095 days (3 years)

Actually, in the field there is variation in the number and proportion of the various immature and mature stages found at any one time. Variation is yearly and individual, and the time-range of most stages found in the soil is about double the actual range of any individual stage. Those reared in the laboratory may vary decidedly from the same stage in the field. In midsummer, development will be much more rapid in the field. However, practically all of the individuals pass the first winter in the second instar, the second winter in the third instar and the third winter as beetles.

BROODS

There is almost no overlapping of developmental stages in any one area. Practically the entire *P. anxia* population is in the same developmental rhythm, with only the one stage occurring in the same season. The year the beetles emerge from the soil is known as a "flight year" and the enormous numbers of beetles may cause severe damage by destroying the foliage of trees and shrubs. The next season, known as the "outbreak year," the second instar grubs are most abundant and cause severe losses to cultivated crops and pastures. The developmental sequence of all Phyllophaga in one area is constant for that area and has been termed a "brood". There are three broods known to occur in Eastern Canada.

These three broods, A, B and C have a three-year developmental rhythm, which is distinct in each case. Each brood covers a separate geographical area with very little overlapping. The "outbreak" year is different in each brood. There are two broods, A and C, in Ontario but all three occur in Quebec. (See Figure 1).

Brood A

This brood occurs along the upper Ottawa River Valley in Quebec from Papineau County westward and infestations of economic importance are found far up the Gatineau Valley. It also extends from extreme eastern Ontario to Lake Huron, with a number of variable, exceptionally severe concentrations. The northern limits extend past Algonquin Park

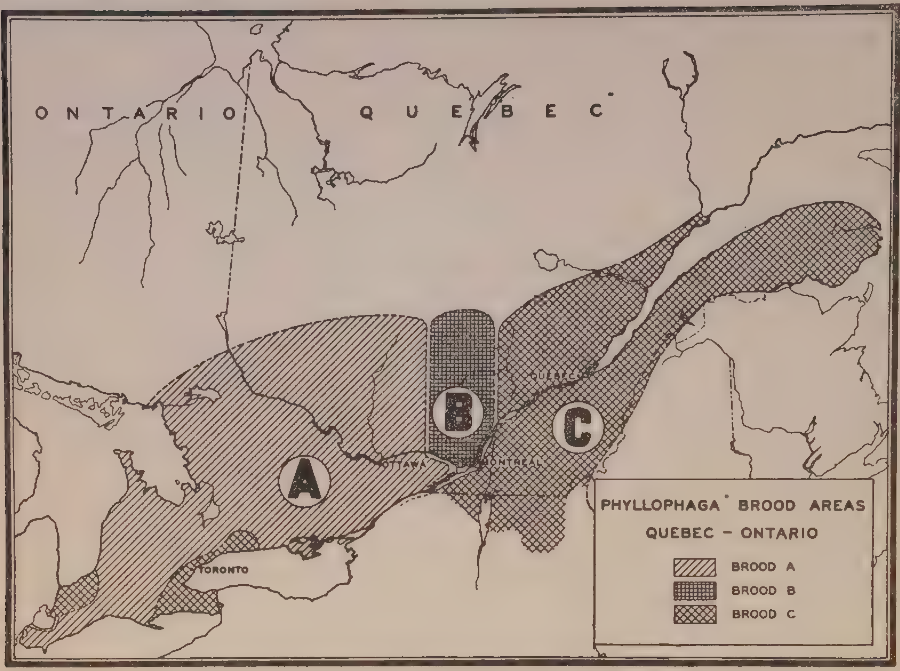

FIGURE 1

and the southern limits are along the Great Lakes, except for those areas occupied by Brood C. A large number of counties are involved but the counties of Ontario, York and Peel have Brood C over the southern half and Brood A over the northern half (See Figure 1). *P. anxia* is the only species of economic importance where this brood occurs in Quebec and over eastern Ontario, extending to Hastings County. Between the western border of Hastings County and a line drawn from the eastern side of the Bruce Peninsula to a point along Lake Ontario somewhat eastward from Hamilton, two species, *P. anxia* and *P. fusca* Froe., are dominant, the proportions varying somewhat from point to point. Westward from this line at least four more species occur, including *P. rugosa* Mels., *P. futilis* Lec., *P. inversa* Horn. and *P. hirticula* Knoch. A major flight in the Brood A territory occurred in 1947 and the next "outbreak" year will be 1948. (See Figure 2).

Brood B

So far as is now known Brood B occurs only over the Montreal and Montreal-North area in Quebec between the areas occupied by Broods A and C (See Figure 1). The counties involved are Jacques-Cartier, Laval, Terrebonne, Two Mountains and Argenteuil. The area of significant infestation is a mixed farming and market garden district.

The next major flight will occur during 1948 and the next "outbreak" year during 1949; *P. anxia* is the only common species here.

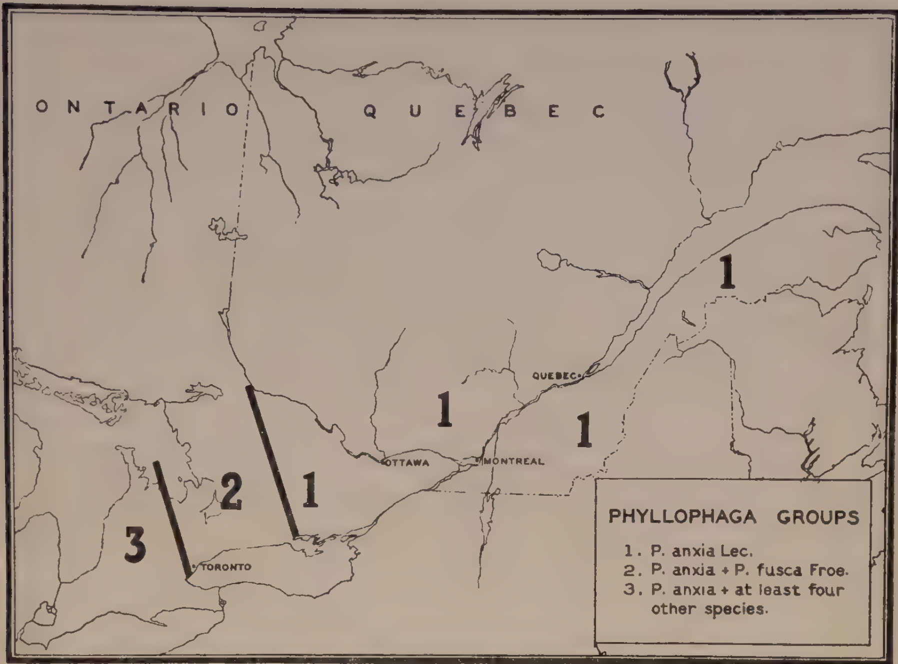

FIGURE 2

Brood C

In Quebec, Brood C is found from the vicinity of Berthierville along the north shore of the St. Lawrence River toward Quebec City. Except for small, localized areas, it also covers all of the province south and east of the river to the international boundary, reaching its greatest economic importance in southern Quebec and the rolling hills of the eastern townships.

In Ontario this brood is found throughout Durham, and the southern portions of Ontario, York and Peel counties, the entire Niagara Peninsula, and extends westward to near the central part of Simcoe and Lambton counties. In the Toronto-Oshawa area *P. anxia* usually is overshadowed by *P. rugosa*, *P. fusca* and *P. futilis*.

It is readily apparent that Brood C usually occurs in the more southern areas close to the international boundary. The states adjacent to Quebec and Ontario have a similar brood development.

The year 1947 was an "outbreak" year and the next major beetle flight will occur during 1949.

Table 3 shows how the developmental rhythm of *P. anxia* and other species of June beetles in the three brood areas can be used to forecast beetle and white grub outbreaks and year of maximum damage.

FEEDING HABITS AND FOOD PLANTS

The adults of *P. anxia* Lec. feed entirely above ground while the larvae or white grubs are subterranean feeders.

Table 3.—The rhythm of outbreaks of *Phyllophaga anxia* Lec. and other species in the three broods

	Brood A	Brood B	Brood C
"Flight" years (beetles)	1944 1947 1950 1953	1945 1948 1951 1954	1946 1949 1952 1955
"Outbreak" years (grubs)	1945 1948 1951 1954	1946 1949 1952 1955	1947 1950 1953 1956

Beetles

During the latter half of May the majority of the beetles emerge from the soil and commence to fly and feed as soon as foliage has developed sufficiently. Under 50 degrees F. flight activity is restricted but with temperatures above 50 degrees, activity increases. Peak flights and extensive feeding frequently occur when evening temperatures rise above 60 degrees.

The beetles feed upon foliage of the various food plants. They prefer tender, developing foliage about one-third grown, although many leaves are eaten when fully developed. During a major flight, beetles swarm over trees and shrubs in large numbers and many may be found upon a single leaf. They typically feed from the edges of leaves, biting through the lateral and midribs, often leaving only the base of the leaf petiole. Where beetles are very numerous and much of the foliage is fully-developed they destroy many leaves by merely biting through the petioles, causing the leaves to drop. As a general rule the beetles fly and feed in the tops of medium or large trees, defoliating the top twigs first. The inner foliage near the trunk is usually the last to be attacked. After a major flight it is quite common to observe hundreds of large trees completely, and thousands of smaller trees and shrubs partially defoliated.

A fairly complete list of the food plants of *P. anxia* adults follows:

Preferred food—
- American elm
- Oak (all local spp.)
- Large-toothed poplar
- Common lilac (flower petals)
- Rose (esp. hybrid tea)
- White ash
- Aspen
- Butternut
- Apple (flower petals)
- Raspberry (wild and cultiv.)

Second choice—
- Basswood
- Willow (Salix spp.)
- Pear (wild and cultiv.)
- Juneberry (Amelanchier)
- Snowball (garden)
- Chokecherry
- Alder (Alnus spp.)
- Mountain ash
- Hawthorne (Crataegus spp.)
- Walnut
- Birch (all local spp.)
- Dogwood
- Garden cherry (all types)
- Elderberry (Sambucus spp.)

Seldom fed upon—
- Common evergreens
- Common maples
- Horse chestnut
- Sumac
- Balsam poplar
- Rock elm
- Slippery elm
- Beech

The fact that June beetles do not feed on sugar maple is an important consideration when making ornamental plantings around dwellings or along highways. The planting of white or red oak, white ash, mountain ash or American elm may actually attract June beetles in large numbers and may be responsible for local white grub infestations.

Larvae or White Grubs

The immature stages or white grubs feed on a wider selection of plants than do the adults. In fact they are almost omnivorous and the limiting factors to total destruction of the roots of any plant are size and toughness of the roots. Actual feeding habits have been discussed in some detail by the author (15). First-year white grubs, although more numerous than second- or third-year grubs, are quite small until the late summer and cause only minor damage. During the second summer, the grubs feed from May until late September or early October, causing very serious damage to roots, underground stems and tubers. During the third year, grubs are not so numerous per unit area as in the first or second year and because of this and the fact that they feed relatively little they never cause serious losses.

The fundamental reason for the excessive destructiveness of grubs feeding on fibrous-rooted plants like timothy is that they feed gregariously, moving forward in a horizontal plane about two inches under the soil surface. Roots are sheared through, resulting in the death of the plant, although only a fraction of the root has actually been devoured. As plants are destroyed the grubs move forward for fresh roots.

Feeding in fleshy roots or tubers usually consists of surface lesions or deep excavations into the root tissue, but the entire plant is not necessarily killed. Potatoes are a preferred food and the entire crop may be destroyed if planted in heavily-infested sod land. Feeding on the roots of young evergreens or roots of young fruit trees, the grubs cut the smaller roots at various levels and sometimes devour all the root bark from the larger ones. Grubs seldom damage Leguminoseae because the roots are apparently tough and relatively unattractive.

CONTROL

Control measures in some detail were discussed in Bulletin 668 (21) and Pamphlet 39 (22), Division of Entomology, Department of Agriculture, Ottawa. The present discussion applies particularly to *P. anxia* but it will apply equally well to all species of the genus *Phyllophaga* in Eastern Canada.

Natural Control

Practically all of the known natural enemies of *P. anxia* in southern Quebec were discussed by Petch and Hammond (28, 29) and these will be somewhat similar for the remainder of Quebec and all of Ontario.

Natural enemies play an important part in destroying both white grubs and adult beetles but the practical agriculturist cannot do much to increase their effectiveness, especially that of the insect parasites and predators. However, he can assist migratory birds and common mammals to destroy the white grubs. Many of the common migratory birds feed upon grubs and beetles and working the land to expose the insects in the period when the predators are present, will often increase their effectiveness.

The common skunk should be protected in a district infested by white grubs. The skunk destroys enormous numbers of white grubs, June beetles, grasshoppers and crickets during the period when these pests are active.

Hogs will destroy large numbers of white grubs when allowed the run of infested fields but ordinarily they cannot be used, except in the case of fields which are to be ploughed.

Weather is an important factor in the natural control of *P. anxia.* Although white grubs are usually found in greatest concentrations in fields which are relatively dry, extreme dry weather for a prolonged period destroys large numbers of immature larvae. On the other hand the flooding of pastures or meadows for a period of several weeks when white grubs are active will virtually eliminate the pests.

CONTROL MEASURES

Control of Beetles

Ploughing, discing or other cultural operations are not recommended for the control of the beetles in the soil because the control obtained is not sufficiently high to warrant the cost or effort. Light traps also are unsatisfactory.

Unsightly defoliation of trees and shrubs and serious reduction in annual growth may be avoided by spraying the foliage with poisons just before heavy flights of June beetles start in May. At the same time reductions in the future number of white grubs in the immediate area will be effected. Arsenate of lead, 1 pound to 20 gallons of water applied on May 20, and where necessary, a second application one week later, will greatly reduce the numbers of beetles. Spraying with a miscible form of DDT is also effective but it should not be applied to rose or raspberry bushes because of the danger of destroying pollinating bees.

Control of Pupae

Maheux and Gauthier (26) advocate the destruction of pupae as a main control for *Phyllophaga* in Quebec, based largely on the vulnerability of this inactive stage to exposure by breakage of the pupal cell.

Pupae are formed in midsummer and it is therefore necessary to apply the cultural program at this time, a procedure which means loss of a part or all of the season's crop on that land. Very deep ploughing such as is necessary to reach the level of the pupae in the subsoil is costly and laborious and cannot be applied to many farms. In the light of recent findings in Eastern Canada and elsewhere the deep ploughing cannot be considered as conducive to highest crop yields.

Control of White Grubs

In contemplating any direct control program it is obviously most important to destroy the grubs before they have caused their maximum damage to crops. The two most favourable periods are either during the late summer when the first year grubs are active or the early summer of second year grub activity. At either time the grubs are near the surface of the soil and can be dealt with most efficiently by plough and disc

Cultural

Although ordinary cultural practices, when applied at strategic periods during the season, will destroy large numbers of white grubs in various stages of development, these cannot always be relied upon to give adequate control.

Special treatment of sod in pastures or meadows is necessary when converting this land to hoed crops provided the soil contains two or more white grubs (first-year) per cubic foot. Where it is not possible to apply the following treatment to first-year grubs during late August or early September it can be applied during the early part of the next year, just before planting.

The land should be ploughed not deeper than three inches and this followed as soon as possible with five applications of the disc-harrow, weighting the discs to cut moderately deep. However, where a tractor is used for power, the number of discings may be reduced to four because of the mechanical disturbance caused by the tractor.

The aim of this control is to reduce the white grub population, by mechanical injury, to a point so low that the grubs will not be sufficiently numerous to destroy susceptible crops such as corn, timothy and strawberries.

Deserted farms, particularly with large pasture areas, add to the white grub control problem in a district which otherwise may be relatively free from white grub infestation. To prevent beetles migrating from such areas it is advantageous to spray isolated trees near the infested land just prior to a June beetle flight. It is also advisable to plant as much as possible of the arable idle land to alfalfa.

Crop Rotations

Because of the developmental rhythm of white grubs and the fact that flight years and outbreak years can be forecast far in the future, the rotation of crops can be exceedingly valuable in preventing crop losses and destroying white grubs. Any rotation must be planned to take advantage of the fact that the adult beetles deposit most of their eggs in pastures, hay meadows and poorly cultivated fields where the vegetation is dense and inclined to be soddy. Such lands are almost sure to be infested with second-year white grubs the next season and should not be prepared for seeding to anything but immune crops unless the shallow ploughing-multiple discing program is carried out. Cultivated lands which are free of grass and dense weed growth will receive very few eggs and consequently will be reasonably free of grubs.

Rotations, therefore, must be planned to provide for at least one of the following:

1. The cultivation of sod or soddy lands the year before or early in the flight year.
2. The use of the shallow ploughing-multiple discing program on sod lands if they are to be seeded to susceptible crops in the outbreak year.
3. The seeding of immune crops in the flight year or outbreak year.

If the first condition is strictly adhered to, the others can be ignored, since there will be few grubs in the soil. On the other hand, if sod lands must be cultivated in the outbreak year, then one or both of the alternatives must be adopted.

There are several good rotations which can be adopted, and which are advocated by the Central Experimental Farm, Ottawa, for use in Eastern Canada*. Because the insect has a 3-year rhythmic cycle, the most satisfactory rotations are those of 3 and 6 years. If these are planned to fit in with the white grub brood development in any district it should be possible to produce crops with a minimum of loss without any other control measure being used.

A three-year rotation which is recommended is a corn or roots-grain-clover hay rotation. In a white grub infested area the grain and clover should be planted in the flight year when the beetles are abundant and laying their eggs. The thorough cultivation following corn or root crops will reduce the number of eggs being laid in the field. The clover hay grown in the outbreak year when the grubs are most likely to cause damage, is an immune crop. The corn or roots seeded the following year will not be injured by the last stage grubs. Such a rotation should be used on the lighter soils and higher ground where grubs are likely to be most abundant.

Four- and five-year rotations can be used but are likely to suffer slight losses when the crop and cultural practices come at the wrong time in the rhythm of the white grub brood. This can be remedied by using the shallow ploughing-multiple discing control following those seasons when the flight years coincide with the hay or pasture year of the rotation.

Any rotation that includes more than two successive years in hay or pasture other than legume hay is not entirely satisfactory for areas subject to severe infestations of white grubs.

Strawberry plantations are likely to be severely injured by white grubs, especially during the first year of planting and where it is necessary to plant in sod land of the previous year. Where one or more grubs per cubic foot are found the shallow ploughing-multiple discing treatment should be used before planting.

In the case of gardens which are too small to work with horses or tractor it may be necessary to remove and destroy white grubs with digging tools. As a preventive measure, weeds, particularly the grassy types, should be kept down to a minimum, both in the garden and around the edges. The soil of gardens bothered periodically by white grubs may be treated with arsenate of lead applied at the rate of one pound per 1000 square feet and working it into the top 3 or 4 inches.

The newer, volatile soil fumigants such as methyl bromide, chloropicrin, dichloropropane-dichloropropene and ethylene dibromide give promise as control agents for white grubs when applied with a soil injector. However, these should not be used until the operator is certain the results obtained will justify the cost. They are practical only under conditions of intensive cultivation.

DDT (dichloro-diphenyl-trichloroethane) and benzene hexachloride (666) have both shown promise against white grubs over rough, non-arable pastures where most soil insecticides have been impracticable. Further testing will be necessary before final recommendations can be made.

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* Bulletin 163, New Series.

SUMMARY

Early records of white grub damage in Quebec and Ontario were very spotty and irregular. They are too few to give an accurate picture of the actual damage and crop loss experienced.

Throughout Quebec and much of Ontario the principal species of June beetle concerned is *P. anxia* Lec., with several additional species in central and southwestern Ontario. *Phyllophaga anxia* is found in every province of Canada and in Labrador, Newfoundland and some parts of the Northwest Territories. It is a hardy species and occurs as far north at least as the known limits of agriculture.

All species of June beetles found in Eastern Canada have a three-year life cycle and these cycles do not overlap in any one area. However, the life-history stages do not occur in the same time rhythm in all areas, and these different time rhythms are known as "broods," each confined within fairly definite geographical limits.

There are three broods in Quebec and two in Ontario but regardless of the brood development or the species, the second-year white grub is the most destructive stage in the life-history. Both the beetles and white grubs feed on a great variety of plants and the intensity of infestation is closely linked with soil type.

Shallow ploughing-multiple discing of the soil before the second year grub injury, is still recommended as the principal control measure to destroy the grubs before their most injurious phase arrives.

Injury can be avoided by suitable, short-term rotations, the switching of susceptible crops to heavier soils, by the use of clovers instead of timothy hay and by clean culture.

Planting of sugar maples around dwellings and along highways is recommended instead of oak, ash, poplar or American elm because of the beetle menace.

DDT and benzene hexachloride are promising soil treatments. Volatile soil fumigants such as methyl bromide, chloropicrin and dichloropropane-dichloropropene are very effective control agents but the cost is relatively high.

REFERENCES

1. Bethune, C. J. S. Report of insects of the year in the London District. *In* Rept. of the Ent. Soc. Ont. for 1905, p. 12.
2. Buckell, E. R. Insects of the year 1930 in British Columbia. *In* Rept. of the Ent. Soc. Ont. for 1930, p. 30.
3. Caesar, L. Insects of the season in Ontario. *In* Rept. of the Ent. Soc. Ont. for 1912, p. 83.
4. Dupont, E. Essai sur les insectes et les maladies qui affectent le blé, p. 29. Du Hanneton, Montreal. 1857.
5. Evans, J. D. Notes on the occurrence of *Lachnosternas* in 1908. *In* Rept. of the Ent. Soc. Ont. for 1908, p. 66.
6. Fletcher, James. Scarabaeidae-diggers. *In* Rept. of the Ent. Soc. Ont. for 1879, p. 69.
7. Gauthier, G. Observations concerning the white grubs in Quebec. *In* Rept. of the Ent. Soc. Ont. for 1935, pp. 45-48.
8. Gauthier, G. White grub control in Quebec. *In* Rept. of the Ent. Soc. Ont. for 1943, p. 26.
9. Gibson, A. Report on insects of the year, Ottawa District. *In* Rept. of the Ent. Soc. Ont. for 1912, p. 12.

REFERENCES—Concluded

10. Hammond, G. H. The white grub situation in Eastern Canada. *In* Rept. of the Ent. Soc. Ont. for 1930, pp. 69-73.
11. Hammond, G. H. (*a*) Crop selection as an aid to white grub control. *In* Rept. of the Que. Soc. Prot. Plants for 1932-34, p. 70.
    (*b*) A study of white grub losses to individual crops under mixed farming conditions. *In* Rept. of the Que. Soc. Prot. Plants for 1932-34, pp. 72-73.
12. Hammond, G. H. Ploughing and discing for the control of white grubs in Eastern Canada. *In* Rept. of the Ent. Soc. Ont. for 1933, pp. 47-51.
13. Hammond, G. H. White grub surveys in Ontario during 1935. *In* Rept. of the Ent. Soc. Ont. for 1935, pp. 42-45.
14. Hammond, G. H. White grub prospects in Ontario during 1939. *In* Rept. of the Ent. Soc. Ont. for 1939, pp. 87-90.
15. Hammond, G. H. Feeding habits and vertical movements of third year grubs of *Phyllophaga anxia* Lec. *In* Rept. of the Ent. Soc. Ont. for 1940, pp. 20-22.
16. Hammond, G. H. The white grub situation in Ontario during 1941 and a forecast for 1942. *In* Rept. of the Ent. Soc. Ont. for 1941, pp. 16-18.
17. Hammond, G. H. The white grub situation in Ontario during 1942. Also a forecast for 1943. *In* Rept. of the Ent. Soc. Ont. for 1942, pp. 37-39.
18. Hammond, G. H. The feeding habits of *Phyllophaga* spp. larvae. *In* Rept. of the Ent. Soc. Ont. for 1943, pp. 23-26.
19. Hammond, G. H. Chloropicrin as a control for larvae of *Phyllophaga*. A preliminary report. *In* Rept. of the Ent. Soc. Ont. for 1944, pp. 23-26.
20. Hammond, G. H. White grub prospects in Ontario during 1945. *In* Rept. of the Ent. Soc. Ont. for 1945, pp. 15-18.
21. Hammond, G. H. White grubs and their control in Eastern Canada. Dept. Agr., Ottawa, Pub. 668. Farmers' Bull. 86. 1940.
22. Hammond, G. H. Control of white grubs. Dept. Agr., Ottawa, Spec. Pamph. 39. 1940.
23. Hammond, G. H. How to foretell and control outbreaks of white grubs. Dept. Agr. Ottawa, Proc. Pub. 42. 1946.
24. Hudson, H. F. Some notes on the life-history of our common June beetles. *In* Rept. of the Ent. Soc. Ont. for 1919, pp. 81-83.
25. Maheux, G. Insects of the season in Quebec. *In* Rept. of the Ent. Soc. Ont. for 1923, p. 72.
26. Maheux, G., and G. Gauthier. Recherches sur le Hanneton Commun *Phyllophaga* spp. Min. de l'Agr., P.Q., Memoire I : 57-64. 1944.
27. Mitchener, A. V. White grub outbreak in Manitoba. *In* Rept. of the Ent. Soc. Ont. for 1930, p. 15.
28. Petch, C. E., and G. H. Hammond. Notes on the insect parasites of *Phyllophaga anxia* Lec. in the Province of Quebec. *In* Rept. of the Ent. Soc. Ont. for 1924, pp. 24-28.
29. Petch, C. E., and G. H. Hammond. Parasites of white grubs in southern Quebec. A progress report. *In* Rept. of the Ent. Soc. Ont. for 1925, pp. 85-91.
30. Provancher, L. Petite faune entomologique du Canada. Les Coleoptères, Quebec, 1 : 334-337.
31. King, K. M., E. McMillan, and K. E. Stewart. Insects of the season in Saskatchewan. *In* Rept. of the Ent. Soc. Ont. for 1930, pp. 23-27.
32. Saunders, W. Insects affecting the strawberry. *In* Rept. of the Ent. Soc. Ont., for 1872, pp. 17-19.
33. Swaine, J. M. Insects of the season in Quebec. *In* Rept. of the Que. Soc. Prot. Plants for 1909-10, pp. 64-65.

THE DEVELOPMENT OF THE C.E.F. CYCLONE PLOT THRESHER

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In 1938, at the request of the Cereal Division, Central Experimental Farm, Ottawa, work was started on a rod row thresher that could be easily cleaned. The first model was made from a Sirocco type fan housing, equipped with a 6-blade flywheel in place of a fan. Grain was fed through the side of the fan housing near the tips of the rubber-faced blades, which acted as an undershot cylinder, threshed against a fixed rubber-faced plate and discharged into a cyclone without separation from the chaff or straw. Refinements made on this unit during the next two years included pipe framing, a hinged feed pan to facilitate cleaning and the addition of a four step pulley to vary the cylinder speed. Power was supplied by a one-half horse power electric motor. This unit was favourably reported on by the Cereal Division in *Scientific Agriculture* in November, 1942 (3).

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FIGURE 1. 1942 model—Pipe frame, cylinder and cyclone.

FIGURE 2. 1947 model—Motor-driven, rear view feed side.

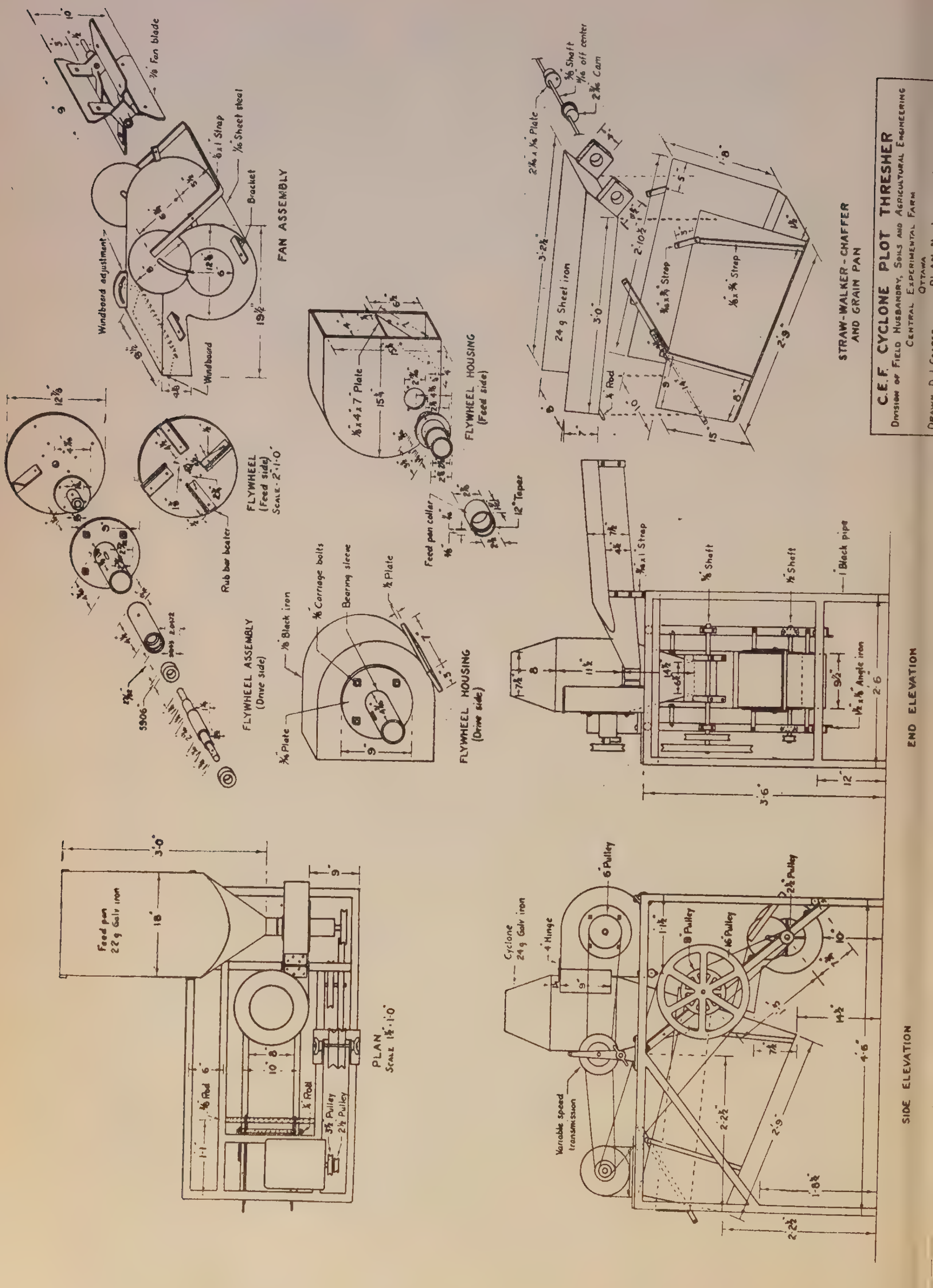
FIGURE 3. 1947 model—Motor-driven, front view drive side.

FIGURE 4. 1947 model—Gas engine drive, with mercury clutch.

The war prevented further work on this type of unit by the Agricultural Engineering staff until 1946, when an unsuccessful attempt was made to eliminate the fixed cyclone which prevented inspection. In this machine the material was delivered directly from the bottom of the cylinder housing on to a separate straw deck and a chaffer sieve. While these experiments were unsuccessful, information secured enabled the designing of a satisfactory model early in 1947. It was found necessary to return to the use of a cyclone separator to control the blast from the cylinder. The required increase in the height of location of the cyclone so as to leave room for a separator below was effected by changing to an overshot type of cylinder. The cyclone was hinged to the cylinder housing, to enable complete inspection and the previous straw deck and chaffer sieve was combined into a single frameless unit, thus eliminating points of seed lodgement. A number of mechanical improvements were made by way of a feed tube, in place of a rectangular feed opening, close fitting of the feed table to the feed tube, sealed main bearings, and ready adjustment of cylinder speed, feed tube clearance and air blast to the cleaning mechanism.

In operation the four rubber-faced blades on the overshot cylinder produce a flailing action in passing the feed tube which serves as a shelling plate. An air inlet at the rear of the cylinder housing permits entry of sufficient air to entirely clean the cylinder and to blow the threshed material over into the cyclone which delivers it to the straw deck. The combination straw deck and chaffer sieve has the rotary motion of a straw deck at the front end and the reciprocating motion of a chaffer sieve at the rear of the deck. The chaffer has two-inch width of openings to allow for a wide variation in the class of material handled. As with any thresher careful feeding of the machine is essential. Best results are secured by keeping the feed tube two-thirds to three-quarters full and feeding heavier straw slowly enough to enable clearance from the cyclone.

FIGURE 5. 1947 model—Flywheel housing and assembly.


C.E.F. CYCLONE PLOT THRESHER
Division of Field Husbandry, Soils and Agricultural Engineering
Central Experimental Farm
Ottawa
FAN ASSEMBLY
Windboard adjustment
Windboard
Bracket
FLYWHEEL
(Feed side)
FLYWHEEL ASSEMBLY
(Drive side)
Rub bar beater
Carriage bolts
Bearing sleeve
FLYWHEEL HOUSING
(Drive side)
FLYWHEEL HOUSING
(Feed side)
Feed pan collar
12° Taper
STRAW-WALKER-CHAFFER
AND GRAIN PAN
24 g Sheet iron
Feed pan
22 g Galv iron
PLAN
END ELEVATION
1 Black pipe
Cyclone
24 g Galv iron
6 Pulley
8 Pulley
16 Pulley
Variable speed
transmission
SIDE ELEVATION

Three units of this latest design were built in 1947 each with a one-horse motor or with a mercury clutch for gasoline engine drive. One electric motor drive unit was sent to the Dominion Experimental Station at Lennoxville, Que., for tests in 1947; one was retained at Ottawa for use of the Field Husbandry, Cereal and Forage Crops Divisions, and the third unit, equipped with gasoline engine drive, was sent to the Dominion Experimental Sub-station at Fort Vermilion, Alberta.

The experience of the past season indicates that this type of unit is suitable for threshing rod rows from varietal plots or other small samples of wheat, oats, barley, flax, beans, peas, and certain forage crops, such as agropyrum-wheat crosses and other forage crops with larger seeds.

Plans, specifications and operating instructions for the C.E.F. Cyclone Plot Thresher are available from the Division of Field Husbandry, Soils and Agricultural Engineering, Central Experimental Farm, Ottawa.

REFERENCE

1. Fraser, J. G. C. *et al.* New Miniature Thresher. Sci. Agri. 23 : 3. 1942.

STUNT-MOTTLE VIRUS DISEASE OF CHRYSANTHEMUM[1]

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[Received for publication February 17, 1948]

In the autumn of 1945, N. May, gardener of the Dominion Experimental Station at Summerland, B.C., brought to the writer's attention an abnormal condition in *Chrysanthemum morifolium* Ram. The condition had appeared suddenly in three of the several chrysanthemum varieties being grown in a local greenhouse. Since that time symptoms have been noted in eleven varieties.

The symptom picture varies considerably with variety, but in all varieties it apparently differs in some respects from that described for the chrysanthemum stunt recently reported in Eastern and Mid-Western North America (1). The most consistent symptoms are those that appear in the foliage. All affected varieties display a mottling that roughly borders the veins of the leaves and that may become a distinct vein-clearing (Fig. 1). In certain varieties, the mottle is accompanied by a dwarfing and distortion of all leaves produced after infection occurs. Plant growth is dwarfed in all varieties. Dwarfed and ragged flower-heads have been produced by seven of the varieties. Neither early blooming nor loss of petal colour has been observed. The descriptive name "stunt-mottle" is suggested for this disease.

The disease is transmitted readily by grafting. In June, 1947, four young healthy plants of the susceptible variety Mrs. T. W. Pockett were planted out-of-doors as close as possible to young diseased plants of the same variety, and one main stem of each healthy plant was grafted to the adjacent diseased plant. Observations at the end of September disclosed that the grafted stems of healthy plants had produced only very stunted growth and small, typically distorted and mottled leaves above the point of graft union. Meanwhile the ungrafted stems of the same healthy plants had continued normal growth (Fig. 2). Ungrafted check plants of the same variety grown a hundred yards distant also remained free of symptoms. All plants were removed to the greenhouse in October and allowed to bloom. The grafted branches produced typically stunted, ragged flower heads, while ungrafted branches and plants produced normal flower heads.

When plants of the symptomless varieties Louisa Pockett and Yellow Favourite were grafted to diseased plants of Mrs. T. W. Pockett and Appert in a similar manner, there was no transfer of symptoms.

The varieties in which symptoms have been noted thus far include: Mrs. Agnes Holden, Appert, Betsey Ross, Corinthia, Crimson Pockett, Joseph Bradford, Mrs. Hadgood, Mrs. Leslie Davis, Mrs. T. W. Pockett, Peace, and Yellow Turner. Symptomless varieties include: Anne Baxter, Connie Mayhew, Edith Cavell, Louisa Pockett, Mrs. E. R. Russland, White Favourite, Yellow Favourite and Yellow Pockett.

REFERENCE

1. Dimock, A. W. Chrysanthemum Stunt. N.Y. State Flower Growers Inc., Bull. 26. 1947.

[1] Contribution No. 932 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.
[2] Plant Pathologist.

FIGURE 1. Diseased and healthy chrysanthemum leaves of various ages. The four upper leaves are from inoculated plant, showing dwarfing, distortion, mottle and vein-clearing.

FIGURE 2. A test plant three months after inoculation by grafting. Stem at left has produced typical disease symptoms above point of graft union. Stem at right, not grafted.

2,4-D AS A FACTOR IN INCREASING WIREWORM DAMAGE OF WHEAT[1]

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[Received for publication April 29, 1948]

It is known that crop damage by the prairie grain wireworm, *Ctenicera aeripennis destructor* Brown is more pronounced and severe if either germination is delayed or early growth of the young plant is retarded. Drouth, sub-optimum temperatures, formalin seed treatments for smut control, and deep seeding are often important factors in retarding germination and growth and in permitting increased wireworm damage.

In 1947 a new factor, which appeared instrumental in increasing wireworm damage, was observed. In an experiment conducted by the Soils Research Laboratory, at the Dominion Experimental Station, Swift Current, Saskatchewan, 2,4-Dichlorphenoxyacetic acid was sprayed on two plots at respectively 1 and 2 pounds of acid per acre. A third plot between the two treated plots served as a check. The 2,4-D was applied to the soil May 15. On four successive dates, May 16, June 2, June 17 and July 3, wheat, in addition to other crops, was seeded across the three plots (1).

Casual observations on June 15 indicated that there was a greater degree of wireworm damage to the emerged wheat plants in the 2,4-D treated plots than in the check plot. Consequently a more detailed examination was made on the same date. This revealed that the wheat kernels seeded on May 16 had disintegrated to such an extent that wireworm seed damage could not be determined. However, in the 2,4-D treated plots seeded on June 2, the number of seeds, which failed to germinate due to wireworm injury, was three times as great as in the check plot seeded on the same date. Counts of the emerged plants of the June 2 seeding were not feasible owing to the immaturity of the seedlings, although the damage appeared to be about as severe as in the plots seeded on May 16. The data from the latter are given in Table 1. The crops seeded on June 17 and July 3 were examined at a later date but had suffered very little damage, presumably because they were sown after the period of maximum wireworm activity.

[1] Contribution No. 2535 from the Division of Entomology, Science Service, Department of Agriculture.
[2] Technical Officer, Dominion Entomological Laboratory, Saskatoon, Sask.

Table 1.—Wireworm damage to emerged wheat plants in soil sprayed with 2,4-D May 15, seeded May 16

(Average of ten 1/40,000 acre samples)

	Check	2,4-D per acre	
		1 lb.	2 lb.
Total plants	24.0	16.0	18.0
Wireworm killed plants	1.2	5.0	4.8
Percentage killed	5	31	27

In both rates of treatment the germination and growth of the wheat seeded on the first two dates were distinctly retarded in relation to the crop on the untreated plot. Associated with this delayed growth, about 30 per cent of the emerged plants were killed by wireworms while only 5 per cent were damaged in the check plot. Likewise the poorer germination and emergence in the treated plots appear to have been caused to a considerable extent by wireworm damage. Apparently the 2,4-D, by retarding the germination of the seeds and the growth of the plants, was instrumental in permitting increased wireworm damage.

If this observation is substantiated by further evidence, caution is indicated in applying herbicides shortly before or after seeding wireworm-infested fields; otherwise the losses caused by wireworms may nullify or exceed the savings obtained in weed control.

ACKNOWLEDGMENT

Grateful acknowledgment is made to J. L. Doughty, Officer-in-Charge, Soils Research Laboratory, Swift Current, Saskatchewan, for permission to use the observations made on the above experimental area.

REFERENCE

1. Bisal, F. Residual effect of 2,4-dichlorphenoxyacetic acid. Presented to the Western Weed Control Conference, Regina, Sask., November, 1947. 2 pp. Mimeo.

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AGRICULTURAL ENGINEERING

1. Chinese agriculture and its mechanization. James Y. T. Yu. (In Agricultural engineering. Vol. 29, no. 7. July, 1948. pp. 297-98, 300.
2. Artificial shades for livestock in hot climates. C. F. Kelly and N. R. Ittner. (In Agricultural engineering. Vol. 29, no. 6. June, 1948. pp. 239-242)
3. Range shelter and equipment. T. C. Higgins and H. E. Gulvin. Kingston, 1948. fold. il. (Rhode Island state college. Extension service bulletin no. 116)
4. Hay rack and feed trough for weaner calves and yearlings. C. A. Brennen. Carson City, 1948. 13 p. il. (Nevada. University. Agricultural experiment station bulletin no. 178)
5. Electric heating cable for a poultry water supply. C. N. Turner. Ithaca, 1948. 15 p. il. (Cornell extension bulletin 734)
6. The loose housing and feeding of dairy herds. L. J. Smith and others. Pullman, 1948. 21 p. figs. (Washington agricultural experiment station popular bulletin no. 190)
7. The Nevada hay bale stacker. Reno, 1947. fold. figs. (Nevada. University. Agricultural extension service bulletin 95)

AGRICULTURE—ECONOMIC ASPECTS

8. Australian rural industries...... Issued by the Rural bank of New South Wales. Sydney, 1948. 144 p. maps. charts.
   Original planning of this publication by J. G. Crawford. Maps and some of the charts are the work of Miss M. I. Dunbabin.
9. California clingstone peaches; economic status, 1948. Sidney Hoos and H. Fisk Phelps. Berkeley, 1948. 27 p. figs. tabs. (California agricultural experiment station circular 385)
10. Economic aspects of farm mechanization. Costs and performance of tractors and combine harvesters in East and South-East Scotland. D. Witney and H. C. M'Iver. Edinburgh, 1947. 46 p. figs. tabs. (Edinburgh and East of Scotland college of agriculture bulletin no. 9)

AGRICULTURE—HISTORY

11. The first fifty years. Address by Dr. R. D. Sinclair (College of agriculture, University of Alberta) before the Canadian feed manufacturers' association annual meeting at Jasper, Alta. (In Canadian grain journal, Vol. 3, no. 12. July, 1948. pp. 4-5)
12. The social philosophy of Henry Wise Wood, the Canadian agrarian leader. W. L. Morton. (In Agricultural history, Vol. 22, no. 2. April, 1948. pp. 114-123)

BACTERIOLOGY

13. Bergey's manual of determinative bacteriology. Robert S. Breed and others. Sixth edition. Baltimore, Williams & Wilkins company, 1948. xvi, 1529 p.

BEES

14. The language of the bees...... August Krogh. (In Scientific American, August, 1948. pp. 18-21)
15. Beekeeping in New Hampshire. J. R. Kepler. Durham, 1948. 24 p. il. (New Hampshire. University. Extension service bulletin 86)
16. Illinois state beekeepers' association. Forty-fifth and forty-sixth annual report, 1945-1946. Pleasant Plains, n.d. 180 p. il.

BOTANY

17. Practical field ecology; a guide for the botany departments of universities, colleges and schools. R. C. McLean and W. R. Ivimey Cook. London, George Allen & Unwin ltd., 1946. 207 p. figs.
18. Etude de la croissance et de la sexualité de Mercurialis annua L. M. G. Troupin. (In Bulletin de la Société royale de botanique de Belgique. Tome LXXIX. Deuxième série. Tome XXIX, 1947. pp. 96-99)
19. Contributions to a knowledge of the naturalized flora of New Zealand. No. 2. A. J. Healy. (In Royal society of New Zealand. Transactions and proceedings. Vol. 77, part 1, April, 1948. pp. 172-185)
20. Report on the state of taxonomic botany and botanical collections in some areas of Germany since 1939. London, British intelligence subcommittee, 1946. 191 p. Bibliography: pp. 17-75.
21. Aromatic plants of India. Part VI. S. Krishna and R. L. Badhwar. (In Journal of scientific and industrial research. Vol. VII, no. 6, 1948. Supplement, pp. 101-116)
22. Stérilité ou vieillissement & disparition des espèces végétales. E. De Wildeman. Brussels, Palais des académies, 1948. 705 p. [Académie royale de Belgique. Mémoires (sciences). Tome XXIIa]
23. Anatomy and morphology of the vegetative organs of sorghum vulgare. Ernst Artschwager. Wash., 1948. 55 p. figs. (U.S. Department of agriculture. Technical bulletin no. 957)
24. A study of the mycelium and haustoria of the rusts of Abies. Lilian M. Hunter. (In Canadian journal of research. Vol. 26, sec. C. June, 1948. no. 3. pp. 219-238)

CHEMISTRY—CHEMIC TECHNOLOGY

25. The chemical formulary: A collection of valuable, timely, practical, commercial formulae and recipes for making thousands of products in many fields of industry. Vol. VIII. Edited by H. Bennett. Brooklyn, Chemical publishing company, inc., 1948. 448 p.
26. The chemistry and physics of organic pigments. Lyde S. Pratt. New York, John Wiley & sons, inc., 1947. 359 p. figs. tabs. Bibliography: pp. 319-323.
27. Advances in carbohydrate chemistry. Vol. 3. Edited by W. W. Pigman and M. L. Wolfrom. New York, Academic press inc., 1948. 424 p. figs. tabs. References through the text.
28. Flours from oilseeds. (In Food. Vol. XVII, no. 203, August, 1948. pp. 232-233)

COOPERATION

29. Bibliography on cooperation in agriculture. Compiled by Howard B. Turner and Florence C. Bell. Wash., 1948. 178 p. (processed) (U.S. Dept. of agriculture. Library list no. 41)
30. Farmers' cooperatives in our community A. W. McKay. Wash., 1948. 37 p. il. (U.S. Dept. of agriculture. Farm credit administration. Circular E-32)

DAIRY RESEARCH—DAIRY INDUSTRY

31. Pasteurisation—past, present and future. D. M. Smillie. (In Journal of the Society of dairy technology. Vol. 1, no. 3. April, 1948. pp. 147-154)
32. Oleomargarine tax repeal. Hearings before the Committee on agriculture, House of representatives ...... 1948. Wash., Govt. printing office, 1948. 515 p.
33. Forty years of progress in dairy sanitation. R. S. Breed. (In Canadian dairy and ice cream journal. Vol. XXVII. no. 7. July, 1948. pp. 43-9, 80)
34. Making cheese at home. V. E. Scott. Reno, 1947. 15 p. (Nevada. University Agricultural extension service. Bulletin 97)
35. Dairy produce: A summary of figures of production, trade and consumption relating to butter, cheese, preserved milk, casein, eggs, egg products, margarine. London, Commonwealth economic committee, 1948. 106 p. tabs.

ECONOMIC POLICY

36. The Lucas report. Lord Teviot. (In Journal of the farmers' club. Part 5, 1948. pp. 54-68)
37. Final report on foreign aid of the House select committee on foreign aid ...... 1948. Wash., Govt. printing office, 1948. 883 p. (House report no. 1845)

ECONOMIC POLICY—Continued

38. World rubber and its regulation. K. E. Knorr. Stanford University, 1945. 265 p. charts. tabs. Annotated bibliography: pp. 257-260. (Stanford university. Food research institute. Commodity policy studies. No. 6)
39. Agricultural act of 1948. Hearings before the Committee on agriculture and forestry, U.S. Senate ...... 1948. Wash., Govt. printing office, 1948. 468 p.
40. Agricultural act of 1948. Wash., 1948. 13 p. (Public law 897. 80th congress, 2d session)

FEEDING AND FEEDING STUFFS

41. Scientific principles of poultry feeding. E. T. Halnan. London, H.M. stationery office, 1948. 91 p. figs. tabs. (Great Britain. Ministry of agriculture and fisheries. Bulletin no. 7)
42. Feeding dairy cows. Floyd Johnston and others. Ames, 1948. pp. 953-984. figs. tabs. (Iowa state college. Agricultural experiment station. Agricultural extension service. Bulletin P89)
43. Poultry feed formulas. Compiled by the Special poultry feed committee. College Station, 1948. 11 p. (Texas agricultural and mechanical college. Extension service. Circular 243)

FERTILIZERS

44. Granulated fertilizers. D. P. Hopkins. (In Farming; the journal of agricultural progress. Vol. 11. no. 8. August, 1948. pp. 237-241)
45. Radioactive materials in soil-fertilizer research. Frank W. Parker. (In American plant food council, inc. journal. Vol. II, no. 2. April-May-June, 1948. pp. 4-9, 33)
46. The comparative availability of some organic fertilizers. A. Riad and R. M. A. Anwar. Cairo, n.d. 14 p. (Egypt. Ministry of agriculture. Chemical section. Bulletin no. 244)
47. Bibliography of literature on potash as a plant nutrient. Reviewed April 1941 through June 1941. Catherine M. Schmidt and others. Wash., American potash institute, inc., 1948. 66, xix p. (processed)

FOOD—FOOD PRESERVATION

48. Advances in food research. Vol. 1. Edited by E. M. Mrak and George F. Stewart. New York, Academic press, inc., 1948. 459 p. References at ends of contributions. Contributors to Vol. I: George L. Baker; E. C. Bate-Smith; Kenneth C. Beeson; L. E. Clifcorn; Harry L. Fevold; Samuel Lepkovsky; Howard D. Lightbody; Belle Lowe; A. Frank Ross; G. Fred Somers; Earl R. Stadtman; Orville Wyss.
49. Product quality as influenced by enzymes. C. C. Strachan. (In Canadian food industries. Vol. 19, no. 8. August, 1948. pp. 24-31)
50. Danish bacon; how the quality was created and improved. F. H. Petersen. (In Danish foreign office journal, 1948. no. 2. pp. 6-10)
51. Meat for the family ...... J. J. Wanderstock and J. I. Miller. Ithaca, 1947. 100 p. il. (Cornell extension bulletin 732)
52. Improved interplant fresh apple transpot system. Chet Kelso. (In Western canner and packer. Vol. 40, no. 9. August, 1948. pp. 48-9)
53. A rational method for grading food quality. R. P. Plank. (In Food technology. Vol. 2, no. 3. July, 1948. pp. 241-251)

FORESTS AND FORESTRY

54. Intermountain forest and range experiment station. Annual report, 1947. Ogden, Utah, U.S. Dept. of agriculture. Forest service (1948) 109 p. (processed)
55. Trees and products of farm woodlands. J. A. Cope. Ithaca, 1948. 39 p. figs. tabs. (Cornell extension bulletin 722)

GRAIN

56. Rye—a source of daily bread. Leo J. Schaben. (In Foreign agriculture. Vol. 12, no. 8. August, 1948. pp. 163-168)

HORTICULTURE

57. Land and landscape. Brenda Colvin. London, John Murray, 1948. 266 p. figs. plates.
58. Scarlet; a new grape variety for fresh juice and jellies. H. P. Olmo. Berkeley, 1948. 5 p. il. (California. University. Agricultural experiment station. Bulletin 706)
59. Perlette and Delight; two new early maturing seedless table grape varieties. H. P. Olmo. Berkeley, 1948. 7 p. il. (California. University. Agricultural experiment station. Bulletin 705)
60. Dwarf apple and pear trees in the home garden. W. H. Upshall. Toronto, 1948. 17 p. figs. (Ontario. Dept. of agriculture. Bulletin 456)
60a. The fruit year book, 1947. No. 1. London, The Royal horticultural society, 1947. 114 p. plates.
61. Orchard soil management and apple nutrition in Eastern Canada. M. B. Davis and H. Hill. Illustrations by Arthur Kellett. Ottawa, Dept. of agriculture. Experimental farms service. Division of horticulture, 1948. 28 p. tabs. col. plates. (Publication 802. Technical bulletin no. 65). (English and French)
62. The strawberry in Ontario. W. J. Strong. Toronto, 1948. 28 p. figs. (Ontario. Dept. of agriculture. Bulletin 458)
63. Breeding new fruits for Oregon growers. Quentin B. Zielinski. (In Oregon state horticultural society. Proceedings. 1947. pp. 56-62)
64. Construction of glass case for house plants. Montreal, n.d. il. (Montreal botanical garden. Leaflet 9)
65. Fall planting for your garden. W. R. Leslie. (In The country guide, August, 1948. pp. 8, 32-3)
66. Varieties of fruit for New York. Ithaca, 1948. 24 p. (Cornell extension bulletin 733)
67. Cane fruit culture. L. P. Latimer. Durham, 1948. 8 p. il. (New Hampshire. University. Extension service. Circular 289)
68. Ruby Cabernet and Emerald Riesling; two new table-wine grape varieties. H. P. Olmo. Berkeley, 1948. 12 p. il. (California. University. Agricultural experiment station. Bulletin 704)

INSECTS—PESTS—INSECTICIDES

69. Apparatus used in laboratory insecticide tests at Boyce Thompson institute. Albert Hartzell and others. (In Boyce Thomson institute. Contributions. Vol. 15, no. 3. April-June, 1948. pp. 131-140)
70. Control of ants in turf and soil. John C. Schread and Gordon C. Chapman. New Haven, 1948. 23 p. figs. tabs. (Connecticut agricultural experiment station. Bulletin 515)
71. The association of British insecticide manufacturers. Directory, 1948. London, 1948. 92 p.
72. Rat control methods. Prepared by U.S. Dept. of the interior, Fish and wildlife service in cooperation with U.S. Dept. of agriculture. Wash., 1948. 11 p. il. (processed) (U.S. Dept. of agriculture. PA-41)
73. Caterpillars destructive to tomato. A. E. Michelbacher and others. Berkeley, 1948. 47 p. figs. tabs. (California. University. Agricultural experiment station. Bulletin 707)
74. Reactions of mosquitoes to the aircraft environment. M. Laird. (In Royal society of New Zealand. Transactions and proceedings. Vol. 77. Part 1, April, 1948. pp. 93-114)
75. Laboratory studies on the spraying of locusts at rest and in flight. J. S. Kennedy and others. London, British museum (natural history), 1948. 64 p. figs. tabs. (Anti-locust research centre. Anti-locust bulletin 2)
76. Army-ant life and behavior under dry-season conditions with special reference to reproductive functions. II. The appearance and fate of males. T. C. Schneirla (In Zoologica. Vol. 33. Part 2. pp. 89-112. 1948)
77. The control of spider beetles in Western Canada. Warehouse pests. B. N. Smallman and H. E. Gray (Dominion department of agriculture) Issued by The Canadian national millers' association. n.p., 1948. 10 p. figs. (In English and French)
78. Aerial-spray equipment for a Stearman N2S airplane. D. A. Isler. Wash., 1948. 4 p. figs. (processed) (U.S. Dept. of agriculture. Bureau of plant industry, soils, and agricultural engineering. Divisions of agricultural engineering. Information series no. 87)

INSECTS—PESTS—INSECTICIDES—Continued

79. Aerial-spray equipment for a Piper Cub J-3 airplane. Orve K. Hedden. Wash., 1948. 3 p. (processed) figs. (U.S. Dept. of agriculture. Bureau of plant industry, soils, and agricultural engineering. Divisions of agricultural engineering. Information series no. 88)
80. Staining methods for detecting weevil infestation in grain. J. C. Frankenfeld. Wash., 1948. 4 p. il. (processed) (U.S. Dept. of agriculture. Bureau of entomology and plant quarantine. ET-256)
81. Corn earworm resistance in sweet corn inbreds and hybrids. E. V. Walter. Wash., 1948. 22 p. tabs. (processed) (U.S. Dept. of agriculture. Bureau of entomology and plant quarantine. E-745)
82. Field-model aerosol machines. A. H. Yeomans. Wash., 1948. 10 p. figs. (processed) (U.S. Dept. of agriculture. Bureau of entomology and plant quarantine. ET-258)
83. Milky disease for control of Japanese beetle grubs. C. H. Hadley. Wash., 1948. 6 p. figs. (processed) (U.S. Dept. of agriculture. Bureau of entomology and plant quarantine. EC-4)
84. A second Xenophyes from New Zealand (Homoptera: Peloridiidae). Carl J. Drake and J. T. Salmon. Wellington, 1948. pp. 63-67. (Dominion museum records in entomology. Vol. 1, no. 5)
85. Bee-gathered pollen in various localities on the Pacific Coast. G. H. Vansell and F. E. Todd. Wash., 1948. 9 p. (processed) (U.S. Dept. of agriculture. Bureau of entomology and plant quarantine. E-749)
86. Field identification of potato aphids. L. A. Dionne. Ottawa, 1948. 5 p. figs. (Canada. Dept. of agriculture. Science service. Division of entomology processed publication no. 77)
87. Aro gröna hagtornsbladloppan (Psylla peregrina Först.) och rönnbladloppan (Psylla sorbi [L.] Edw.) endast raser av äppelbladloppan (Psylla mali Schmidb.)? Frej Ossiannilsson. Stockholm, 1948. 14 p. figs. (Sweden. Statens växtskyddsanstalt. Meddelande n : r 51)

    English summary: Are the green hawthorn psyllid (Psylla peregrina Först.) and the mountain ash psyllid (Psylla sorbi [L.] Edw.) only races of the applesucker (Psylla mali Schmidb.)?

LAND ECONOMICS

88. A critical review of research in land economics. Leonard A. Salter. Minneapolis, University of Minnesota press, 1948. 258 p. References through the text.

    "While this book deals specifically with research progress and methods in the field of land economics, the author's findings and conclusions offer guides to research workers and students in agricultural economics and the social sciences generally. Dr. Salter has set up certain basic requirements for evaluating research reports. He makes a comprehensive analysis of the research methodology now used by social scientists and land economists, and forcefully presents the case for use of experimental method in these fields . . ." From the book jacket.

LIVE STOCK—BREEDING

89. Sheep science. William Garfield Kammlade. Edited by R. W. Gregory. Chicago, J. B. Lippincott, 1947. 534 p. il. tabs. (Lippincott's agricultural science series)
90. Brooders help save lambs. D. S. Bell and Carl H. Bradford. (In Ohio farm and home research. Vol. 33, no. 250. January-February, 1948. pp. 4-10)
91. List of sires proved in dairy-herd improvement associations, 1948. Compiled by Division of dairy herd improvement investigations, Bureau of dairy industry. Wash., 1948. 256 p. (U.S. Dept. of agriculture. Miscellaneous publication no. 651)

NUTRITION—VITAMINS

92. Levels of carotene and ascorbic acid in Florida-grown foods. R. B. French and O. D. Abbott. Gainesville, 1948. 21 p. tabs. (Florida. University. Agricultural experiment station. Bulletin 444)

PASTURES—RANGES

93. Grass. Yearbook of agriculture, 1948. Wash., U.S. Dept. of agriculture, 1948. 892 p. il. (House doc. no. 480. 80th congress. First session)
94. Reed canary grass. W. J. White, R. M. MacVicar and F. S. Nowosad. Ottawa, 1948. 7 p. il. (Canada. Dept. of agriculture. Publication 805. Circular 177)
95. Sudan grass—summer pasture in a hurry. D. R. Dodd. (In Ohio farm and home research. Vol. 33, no. 252. May-June, 1948. pp. 104-108)
96. The economics of grass conservation. R. N. Dixey. (Proof circulated in advance of the meeting of the Agricultural economics society, July, 1948. pp. 1-14)
97. Worcester veld reserve discoveries. Mud-coated seed helps in the re-establishment of natural pastures . . . (In The farmer's weekly. July 14, 1948. pp. 52-3)
98. Den kjemiske sammensetning av raukløver og timotei på ulike utviklingstrinn. Harald Hvidsten. (Reprint from Tidsskrift for det Norske landbruk. 54. Arg. 1947. pp. 10-42) (Norway. Landbrukshøgskolens institutt for husdyrernaering og fôringslaere. Saertrykk nr. 54, 1947)
    English summary: The composition of red clover and timothy at various stages of growth.
99. Leguminous forage plants. D. H. Robinson. London, Edward Arnold & co., 1947. 119 p. figs.
100. Forage production and grain saving on your farm. Durham, 1948. 6 p. il. (New Hampshire. University. General extension service. Circular 287)
101. Soybeans. F. Dimmock. Ottawa, 1948. 19 p. il. tabs. (Canada. Dept. agriculture. Publication no. 808. Farmers' bulletin 149. Revision, Farmers' bulletin 80)

PHYTOPATHOLOGY

102. Pole rot of tobacco. P. J. Anderson. New Haven, 1948. 19 p. figs. (Connecticut agricultural experiment station bulletin 517)
103. Studies in forest pathology. V. Decay in fir, Abies lasiocarpa and A. amabilis, in the Upper Fraser Region of British Columbia. J. E. Bier, P. J. Salisbury, and R. A. Waldie. Ottawa, 1948. 28 p. figs. tabs. plates.
104. Zerlate followed by fixed copper spray controls tomato disease without injury. W. S. Beach. (In Science for the farmer, June, 1948. Supplement no. 3 to bulletin 488, Pennsylvanic state college, School of agriculture, Agricultural experiment station, State College)
105. Kartoflens sygomme i billeder og tekst. Ernst Gram. Second edition. Prepared by the Danish state experiment station for plant diseases and pests. Copenhagen, Royal Danish agricultural society, 1945. 108 p. col. plates.
    English summary in pocket: Potato diseases and pests.
106. Tentative recommendations for the use of benzene hexachloride in the control of wireworms in tobacco soils. C. J. Fox. Ottawa, 1948. 2 p. (Canada, Dept. of agriculture. Science service. Division of entomology processed publication no. 74)
107. New South Wales. Department of agriculture. Biological branch. Division of science service. Plant disease survey for the twelve month period ending 30th June, 1947. Seventeenth annual report. Sydney (1947) 41 p. (processed)
108. Effect of various brands of sulphur on the control of powdery mildew of cucurbitaceae. Amin Fikry. Cairo, 1948. 33 p. (Egypt. Ministry of agriculture. Technical and scientific service. Bulletin no. 248)
109. Studies on the composite nature of cauliflower mosaic with a special regard to the selective transmission of both viruses in this complex disease by certain aphids. (English summary of publication by B. A. Kvícala) Brno, 1948. 87 p. il. (Czechoslovakia. University school of agriculture and forestry. Series C. 40)
110. Dusting cucumbers to control downy mildew. D. E. Ellis and R. S. Cox. Raleigh, 1948. 15 p. figs. tabs. (North Carolina state college. Agricultural experiment station. Bulletin no. 362)
111. Leaf roll in relation to second-crop seed potato production on Long Island. H. S. Cunningham. Geneva, 1948. 13 p. figs. (New York state agricultural experiment station bulletin no. 731)

PRICES—COSTS

112. Low market milk prices increase milk consumption. R. W. Bartlett. (In Illinois farm economics. May and June, 1948. Nos. 156 and 157. pp. 665-672)
113. Costs and labor in harvesting corn grain and stover. W. E. Keepper and S. A. Dum. State College, 1948. 34 p. figs. tabs. (Pennsylvania state college. School of agriculture. Agricultural experiment station. Bulletin no. 496)

PRICES—COSTS—Continued

114. Meat control. Hearings before a subcommittee of the Committee on banking and currency, U.S. Senate . . . Wash., 1948. 271 p.
115. Costs in keeping a bull compared with artificial breeding. L. F. Miller and R. Herrmann. State College, 1948. 6 p. il. tabs. (Pennsylvania state college. School of agriculture. Agricultural experiment station. Bulletin no. 499)
116. Seasonal price summaries. Fresh fruits and vegetables on 12 Canadian markets, 1947 . . . Ottawa, Dominion department of agriculture. Marketing service. Market information section, n.d. 23 p.
117. A comparative analysis of the costs of operating milk collection routes by can and by tank in California. D. A. Clarke. Berkeley, 1947. 46 p. figs. (Giannini foundation of agricultural economics. Mimeographed report no. 91). At head of title: California. University. College of agriculture. Agricultural experiment experiment station.

REPORTS, MISCELLANEOUS

118. The National farmers' union year book for 1948. London, 1948. 136, 67, 23 p.
119. The Jewish agricultural society, inc. Annual report, 1947. New York, 1947. 31 p.

RESEARCH

120. Auburn conference on the use of radioactive isotopes in agricultural research. Proceedings, 1947. Auburn, The Alabama polytechnic institute, 1948. 146 p. figs. (processed)
121. The new five-year plan (1946-1950) of the Academy of science of the USSR. (In The Australian journal of science. Vol. 10, no. 6. 21 June, 1948. pp. 166-169)
122. Science and the planned state. John R. Baker. London, George Allen & Unwin ltd., 1945. 120 p.
123. The Agricultural research center of the United States department of agriculture; an account of the activities of the Department's largest research station, at Beltsville, Md. Beltsville, 1947. 34 p. (processed)
124. Institut pour l'encouragement de la recherche scientifique dans l'industrie et l'agriculture. I.R.S.I.A. Rapport annuel, 1947. Brussels (1947) 150 p.

RURAL SOCIOLOGY

125. Rural life in Argentina. Carl C. Taylor. Baton Rouge, Louisiana state university press, 1948. 464 p. figs. tabs. Bibliographical note: pp. 453-454.

SOILS—IRRIGATION—DRAINAGE

126. Garden soils; their use and conservation. Arthur B. Beaumont. New York, Orange Judd publishing company, inc., 1948. 280 p. il.
127. Rain on tap . . . Sprinkler systems are now replacing furrow irrigation in B.C. G. E. Valentine. (In Family herald and weekly star, August 18, 1948. p. 3)
128. Water input used for field crops at the United States Scotts Bluff (Nebr.) field station, 1941-44. C. S. Scofield and O. W. Howe. Wash., 1948. 18 p. tabs. (U.S. Dept. agriculture. Circular no. 777)
129. Dyking and drainage. Bruce Dixon. (In Report of the Deputy minister of lands, British Columbia department of lands and forests, 1947. pp. 141-145)
130. Outline of the development of the systematics of soil. Michal Strzemski. (English summary) (Studies on Polish soils. Vol. 6) Pulawy, 1947. 340 p. (Institut national polonais d'économie rurale à Pulawy. Mémoires. T. XVIII. série A. 1947)
131. Soil erosion experiments at State College, Pennsylvania. Nolan F. Farris. State College, 1948. 17 p. figs. (Pennsylvania state college. School of agriculture. Agricultural experiment station. Bulletin 497)

STATISTICAL METHODS

132. Fluctuations in the sheep population of New South Wales, 1860-1940 . . . R. S. G. Rutherford. (In The economic record, Vol. XXIV, no. 46. June, 1948. pp. 56-71)

TRADE—TRADE STATISTICS

133. Belgian Canadian trade directory. Guide économique belgo-canadien. Editor: Henri Fast. Montreal, 1948. 224 p.
134. European trade patterns. Estimated net import requirements of Western Europe in 1948 . . . Report of the House select committee on foreign aid . . . 1948. Wash., Govt. printing office, 1948. 294 p.
135. Operation of the trade agreements program July 1934 to April 1948. Parts I-V. Preliminary draft. Wash., U.S. tariff commission, 1948. 5 parts. (processed)
136. Fruits (noncitrus); production, farm disposition, value, and utilization of sales, 1889-1944. Wash., 1948. 106 p. (processed) (U.S. Dept. of agriculture. Bureau of agricultural economics. CS-27)
137. Laws relating to interstate and foreign commerce. Compiled by Elmer A. Lewis. Wash., Govt. printing office, 1946. 572 p.
138. Vegetable oils and oilseeds; a summary of production, trade and consumption relating to groundnuts, cottonseed, linseed, soya beans, coconut and oil palm products, olive oil, and other oilseeds and oils. London, Commonwealth economic committee, 1948. 108 p. tabs.
139. Vegetables and fruits, no. 1. (A study of current problems in Europe) Wash., Food and agriculture organization of the United Nations, 1948. 34 p. (processed) (FAO commodity series, No. 6)
140. Meat—a commodity review. (In Review of marketing and agricultural economics, Sidney, N.S.W., April, 1948. Vol. 16, no. 4. pp. 158-167)
141. Annuario statistico dell 'agricoltura Italiana 1939-1942. Rome, Istituto centrale di statistica, 1948. 520 p.

VETERINARY MEDICINE

142. Recent research developments in the control of animal diseases. J. L. Millar. (In Saskatchewan agricultural college graduates' association. Ninth series of graduate lectures, 1948. pp. 27-30)
143. Penicillin—the answer to "strep" mastitis? (In New Zealand dairy exporter, Vol. XXIV, no. 1. July, 1948. pp. 4-7)

WEEDS

144. Agricultural weed-no-more. New Winnipeg plant now manufacturing green cross products for modern pest control. (In Manitoba industrial topics. Vol. 8, no. 1. May-June, 1948. pp. 18-19)
145. Chemical control of weeds in South Dakota. L. A. Derscheid and L. M. Stahler. Brookings, 1948. 14 p. (South Dakota state college. Agricultural experiment station. Circular 69)

New Periodicals in Library:

Journal of the Society of dairy technology. Society of dairy technology, London, England.
Monthly bulletin of statistics of the United Nations. Statistical office of the United Nations. Department of economic affairs, Lake Success.
British agricultural bulletin, British council, London, England.
Cranberry world. American cranberry exchange, New York.
Revue de l'agriculture. Ministère de l'agriculture, Brussels.
Milk and food sanitation. International association of milk and food sanitarians. Albany, N.Y.
Plant and soil: International journal of plant nutrition, plant chemistry, soil microbiology and soil-borne plant diseases. Issued under the auspices of the Netherlands society of agricultural science. The Hague.
Field crop abstracts. Commonwealth bureau of pastures and field crops, Aberystwyth, Great Britain.